

# DINOFLAGELLATE CYSTS AND ACRITARCHS FROM THE KIMMERIDGIAN (UPPER JURASSIC) OF ENGLAND, SCOTLAND AND FRANCE

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## I. INTRODUCTION

THIS paper contains an account of assemblages of organic-walled microplankton (dinoflagellates and acritarchs) from the Kimmeridgian of England, Scotland and France. Since an account has already been given of assemblages from the lowest Kimmeridgian, the Baylei Zone (Gitmez, 1970), attention is concentrated on the higher zones: however, additional records from the Baylei Zone are included and data respecting this zone is incorporated into the stratigraphical discussion.

Many of the samples examined were collected by the second author (W.A.S.S.), with the help or under the guidance of a number of other geologists—in Dorset, from Dr. J. C. W. Cope (University of Wales, Swansea); in the French Jura and the Boulonnais, from Professor Derek V. Ager (then of Imperial College, London; now of the University of Wales, Swansea); in Normandy and Le Havre, from Dr. Michel

Riout (Université de Caen); in Lorraine, from M. Pierre L. Maubeuge; and in Skye, from Dr. Dennis Field (University of Nottingham). In addition, a series of samples from the Warlingham borehole of H.M. Geological Survey were made available for study, through the courtesy of the Director, Dr. F. W. Anderson and Dr. H. Ivimey-Cook; and samples from Cromarty and from Oxfordshire and Cambridgeshire were furnished respectively by Dr. W. D. Ian Rolfe (Hunterian Museum, University of Glasgow) and Dr. Robin I. Whatley (University of Wales, Aberystwyth).

Preparation and preliminary study of the samples was done by the first author (G.U.G.), who also prepared most of the diagrams and photographs. The results were worked out jointly. It was found that many species were represented by insufficient individuals for satisfactory description; re-preparation and further study of the samples were therefore to have been undertaken. This was precluded by the destruction by fire of the upper floor of the Geology building of the University of Nottingham in late March, 1970; all wet and dry samples and many microscope slides were lost and the research programme of the second author (W.A.S.S.) so seriously set back that further work on the Kimmeridgian cannot now be envisaged for some years to come. In consequence, it was considered that, since so little is known of the assemblages from these levels, the data currently available should be published forthwith.

In many instances, samples examined did not yield assemblages; relatively pure limestones in particular proved unproductive, the bulk of the assemblages being obtained from clays or argillaceous limestones. Details are given here of the negative as well as of the positive results.

## II. LOCATION AND DESCRIPTION OF SAMPLES

Since full stratigraphic details and sample numbers for the specimens from the Baylei Zone have already been given (Gitmez, 1970), these are summarized only briefly here. Location, position and specimen numbers for higher horizons are given in full. Nottingham University sample numbers are quoted, since these were employed in all notes made by the authors. [The samples themselves were all destroyed in the conflagration.]

The history of the ammonite zonation proposed for the Kimmeridgian of England is outlined in Table 1. The zonation here adopted is based on that of Arkell (1956) and incorporates the modifications introduced by Cope (1967).

### (1) Dorset (South coast):

The clay formation known as the Kimmeridge Clay represents long-continued deposition of muddy sediments. It is not a uniform deposit, for it includes several lithological types which may alternate in rapid succession; in addition to thick clays there are thin bands of mudstone and several prominent "stone-bands", formed by limestones of variable degrees of purity (see Arkell, 1933; Cope, 1967).

The Kimmeridge Clay is well exposed on the Dorset coast, through faulting in Ringstead Bay and again near Osmington Mills which causes repetition of the succession. Around the type locality of Kimmeridge, the Kimmeridge Clay reaches its maximum thickness (495 m), but towards the west, in the Weymouth district, the thickness is nearly halved and inland it reduces to 90 m.



TABLE I

The history of the zonal classification of the Kimmeridgian

FROM ENGLAND, SCOTLAND AND FRANCE

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Oppel 1856-1858	Salfeld 1913-1914	Neaverson 1925	Arkell 1956	Arkell 1956, modified after Cope 1967	Major Units
P O R T L A N D I A N					
UPPER	(Pavlovia pallasioides) (Pavlovia pallasianus) (Pavlovia rotunda)	Pavlovia pallasioides	Pavlovia pallasioides	Pavlovia pallasioides	
		Pavlovia rotunda	Pavlovia rotunda	Pavlovia rotunda	
	Pectinatites pectinatus	Pectinatites pectinatus	Pectinatites pectinatus	Pectinatites pectinatus	
	Virgatites miatschkovensis	Virgatospinctoides nodiferus	Subplanites wheatleyensis	Pectinatites (Arkellites) hudlestoni	
		Virgatospinctoides wheatleyensis	Subplanites grandis	Pectinatites (Virgatospinctoides) wheatleyensis	
			Subplanites spp.	Pectinatites (Virgatospinctoides) scitulus	
	Gravesia irius	Gravesia Zones	Gravesia gigas	Pectinatites (Virgatospinctoides) elegans	
		Gravesia gravesiana	Gravesia gravesiana		
	"Mutabilis"	Aulacostephanus pseudomutabilis	Aulacostephanus pseudomutabilis	Aulacostephanus autissiodorensis	
		Rasenia mutabilis	Rasenia mutabilis	Rasenia mutabilis	Aulacostephanus eudoxus
Tenuilobatus	Rasenia cymodoce	Rasenia mutabilis	Rasenia cymodoce	Aulacostephanoides mutabilis	
	Pictonia baylei	Rasenia cymodoce	Rasenia cymodoce	Rasenia cymodoce	
		Pictonia baylei	Pictonia baylei	Pictonia baylei	Pictonia baylei
O X F O R D I A N					

The samples studied were collected from two areas, the Isle of Purbeck and the Weymouth district (Text-fig. 1). Fourteen samples were examined from the Isle of Purbeck. (The colours are given according to the "Rock Colour Chart", produced by the Geological Society of America [1963] and based on the Munsell System.)

*Autissiodorensis* Zone:

1. KD 221—Shale containing shell fragments, medium grey in colour (N5), from c. 4 ft above Washing Ledge Stone Band, Kimmeridge (National Grid Reference: 909791).

2. KD 224—Clay containing shell fragments, medium dark grey in colour (N4), from 30 ft above Maple Ledge Stone Band, Kimmeridge. (National Grid Reference: 909788.) [Very few microfossils were obtained from this sample.]

3. KD 225—Clay containing shell fragments, medium dark grey in colour (N4), from immediately below the cementstone at the junction of the *Autissiodorensis* and *Elegans* Zones, Kimmeridge. (National Grid Reference: 909789.)

*Elegans* Zone:

4. KD 227—Clay containing shell fragments, medium dark grey in colour (N4), from 25 ft below the Yellow Ledge Stone Band, Kimmeridge. (National Grid Reference: 917780.) [This sample contains few microfossils.]

*Scitulus* Zone:

5. CD 229—Clay, brownish grey in colour (5 YR 4/1), from 6 ft below the Cattle Ledge Stone Band, Cuddle. (National Grid Reference: 917780.)

*Wheatleyensis* Zone:

6. CH 231—Clay, medium grey in colour (N5), from 22 ft below the Black Stone, Clavells Hard. (National Grid Reference: 920778.)

7. RD 234—Clay, medium grey in colour (N4), from 13 ft above the Rope Lake Head Stone Band, Rope Lake Head. (National grid reference: 934785.) [No assemblage was obtained from this sample.]

Boundary of *Pectinatus*-*Hudlestoni* Zones:

8. FD 236—Marl, medium dark grey in colour (N4), from  $\frac{1}{4}$  mile west of Freshwater Steps, (National grid reference: 946773.)

*Pectinatus* Zone:

9. FD 237—Marl, containing shell fragments, medium dark grey in colour (N4), from 2 ft above the Freshwater Steps Stone Band,  $\frac{1}{4}$  mile west of Freshwater Steps. (National grid reference: 946773.)

10. ED 240—Marl containing shell fragments, medium grey in colour (N5), from 30 ft above the Freshwater Steps Stone Band, Egmont Bight. (National Grid reference: 948772).

11. ED 242—Clay, medium dark grey in colour (N4), from 60 ft above Freshwater Steps Stone Band, Egmont Bight. (National grid reference: 948772).

12. HC 243—Clay, medium dark grey in colour (N4), from c. 100 ft below the Rotunda Nodules, in the base of Hounstout Cliff. (National grid reference: 951773).

Rotunda Zone:

13. CP 245—Clay containing shell fragments, medium light grey in colour (N6), from the Rotunda Nodule Bed, Chapmans Pool. (National Grid Reference: 956772).

14. HC 246—Clay, medium grey in colour (N5), from 140 ft below the Massive

Bed, Hounstout cliff (National grid reference: 950774). [Few specimens were obtained from this sample.]

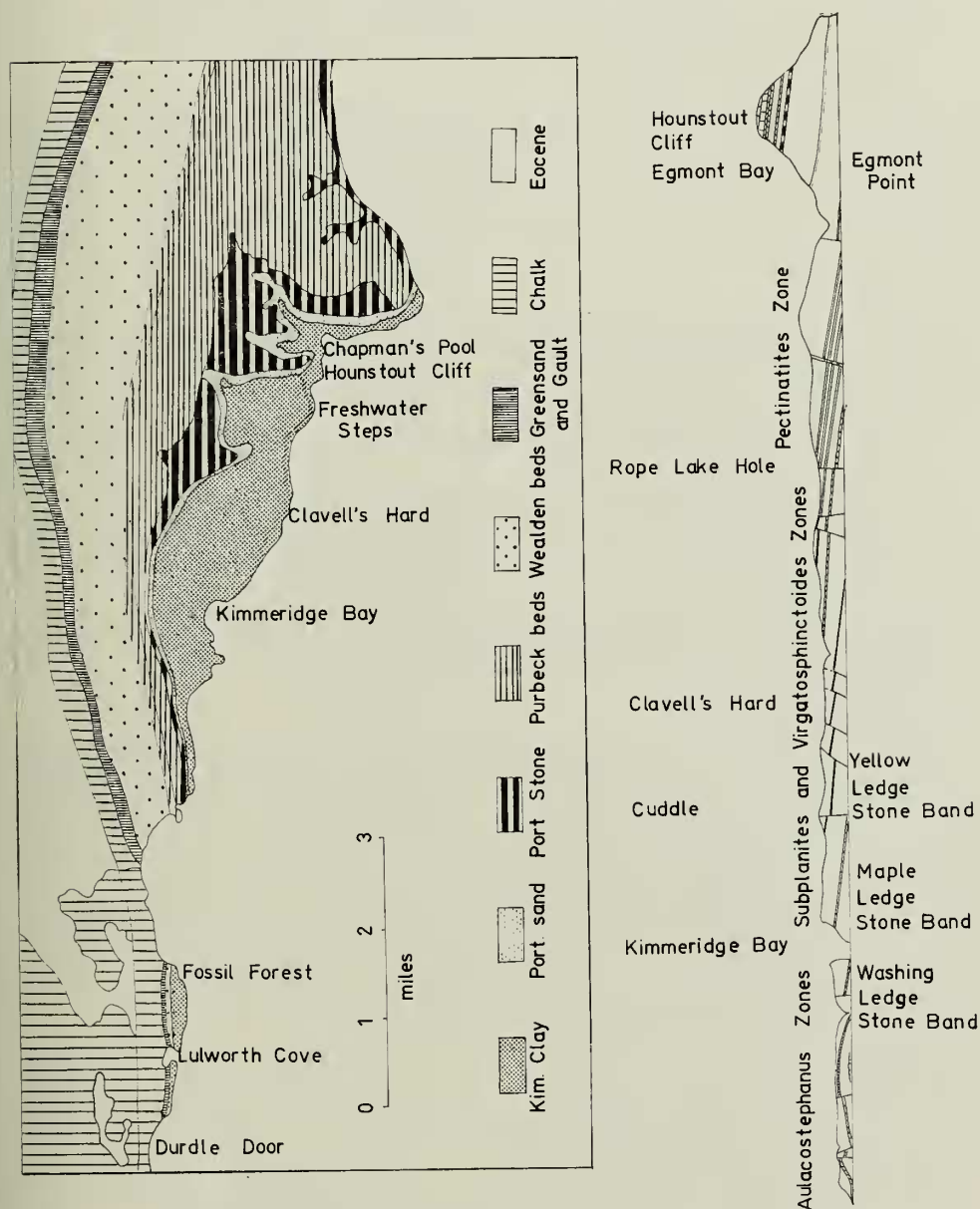


FIG. 1. Sketch map of the Isle of Purbeck, showing the positions of the type sections of the Kimmeridge Clay. Section along the cliffs of Kimmeridge Clay (modified from Arkell, 1933).

In the Weymouth District, the Jurassic rocks have been folded and faulted along a N-S line. The Kimmeridge Clay, after a gap, reappears in Ringstead Bay, rising from the sea and partly hidden by slips of Chalk and Greensand. In this part of the Dorset Coast the Kimmeridge Clay is overlying conformably the Ringstead Coral Bed, at the top of the Oxfordian.

Around Osmington Mills, the exposed clay in the cliffs mainly belongs to the *Mutabilis* and *Pseudomutabilis* Zones: it is quite deeply weathered and much slipped. The *Cymodoce* and *Baylei* Zones, with the Ringstead Coral Bed below, appear from time to time in the foreshore, as a result of periodic stripping of shingle by storms. An account of samples from the *Baylei* Zone at this locality was given earlier (Gitmez, 1970).

(2) Oxfordshire:

The Kimmeridgian, together with the Portland and Purbeck Beds, occupies a small area, being partially concealed by the overlap of the Cretaceous strata. Three samples from the *Pallasioides* Zone were examined; these were collected from a quarry at Littleworth, Wheatley (National grid reference: 595055).

1. LO 352—Clay, medium light grey in colour (N6), from 15 ft below the Wheatley Sands.
2. LO 353—Clay, medium grey in colour (N5), from the quarry.
3. LO 360—Clay, light olive grey in colour (5 Y 6/1), from the top of the Kimmeridgian, Littleworth. [No assemblage was obtained from this sample.]

(3) Cambridgeshire:

There are a few exposures of the Kimmeridge Clay in the north west of this area. Only one sample, from the *Baylei* Zone, was examined from this district: for details see Gitmez, 1970.

(4) Warlingham, Surrey:

The Warlingham borehole was drilled, under contract, in the Geological Survey programme of boring in 1956–1958 and was sited in a field beside the Woldingham Road, Warlingham (National Grid reference: TQ 3476 5719). The boring commenced in Middle Chalk and passed through the Cretaceous and Jurassic rocks, terminating in the Lower Carboniferous at a depth of 5001 ft. At this locality the Kimmeridge Clay is 703 ft thick (between 2284 ft and 2987 ft in depth).

Twenty-nine samples, at 25 ft intervals, from the *Rotunda* Zone to the *Mutabilis* Zone, were studied for their organic-shelled microplankton content. These Kimmeridge Clay samples are between light bluish grey and medium bluish grey in colour (5 B 6/1), representing the zones as follows:

*Rotunda* Zone:

1. WB 29 from 2285'7 " depth.
2. WB 28 „ 2310'6 " depth.
3. WB 27 „ 2335'0 " depth.

*Pectinatus* Zone:

4. WB 26 from 2359'9 " depth.
5. WB 25 „ 2384'9 " depth. [Few specimens obtained.]
6. WB 24 „ 2409'9 " depth.

## Hudlestoni Zone:

- 7. WB 23 from 2434'6 " depth.
- 8. WB 22 „ 2459'6 " depth. [Few specimens obtained.]
- 9. WB 21 „ 2485'0 " depth. [Few specimens obtained.]

## Wheatleyensis Zone:

- 10. WB 20 from 2510'0 " depth.
- 11. WB 19 „ 2535'3 " depth.
- 12. WB 18 „ 2560'0 " depth.

## Scitulus Zone:

- 13. WB 17 from 2584'9 " depth.
- 14. WB 16 „ 2610'0 " depth.

## Elegans Zone:

- 15. WB 15 from 2635'3 " depth.

## Autissiodorensis Zone:

- 16. WB 14 from 2660'1 " depth.
- 17. WB 13 „ 2684'3 " depth.
- 18. WB 12 „ 2709'3 " depth. [Few specimens obtained.]

## Eudoxus Zone:

- 19. WB 11 from 2734'11 " depth.
- 20. WB 10 „ 2760'5 " depth.
- 21. WB 9 „ 2785'2 " depth.
- 22. WB 8 „ 2810'6 " depth.
- 23. WB 7 „ 2834'7 " depth.
- 24. WB 6 „ 2860'0 " depth.
- 25. WB 5 „ 2885'1 " depth.
- 26. WB 4 „ 2910'6 " depth.

## Mutabilis Zone:

- 27. WB 3 from 2935'2 " depth.
- 28. WB 2 „ 2959'5 " depth.
- 29. WB 1 „ 2984'7 " depth.

## (5) Isle of Skye (Staffin Bay):

Three samples were examined from the Baylei Zone of Staffin Bay; these have been fully described by Gitmez, 1970.

## (6) Eathie Haven (South of Cromarty):

The Kimmeridgian strata are visible in a narrow shore strip exposed only at low tide. The beds consist of carbonaceous shales, sandstones, bituminous shales and limestones. The total thickness has been calculated as approximately 38 m (Waterston, 1951, p. 33); the apparent thickness is less than the real thickness, because of the displacements consequent upon folding, which render it difficult to determine the thickness accurately (Text-fig. 2 a, b). Only one sample, from the Cymodoce Zone, was examined:

CS 421—Shale, olive black in colour (5 Y 2/1), from the first Meleagrinnella Band of Eathie. (National grid reference: 778636.)

## (7) The Boulonnais, Pas-de-Calais, France:

The Kimmeridgian rocks are well exposed along the coast of the Boulonnais (see

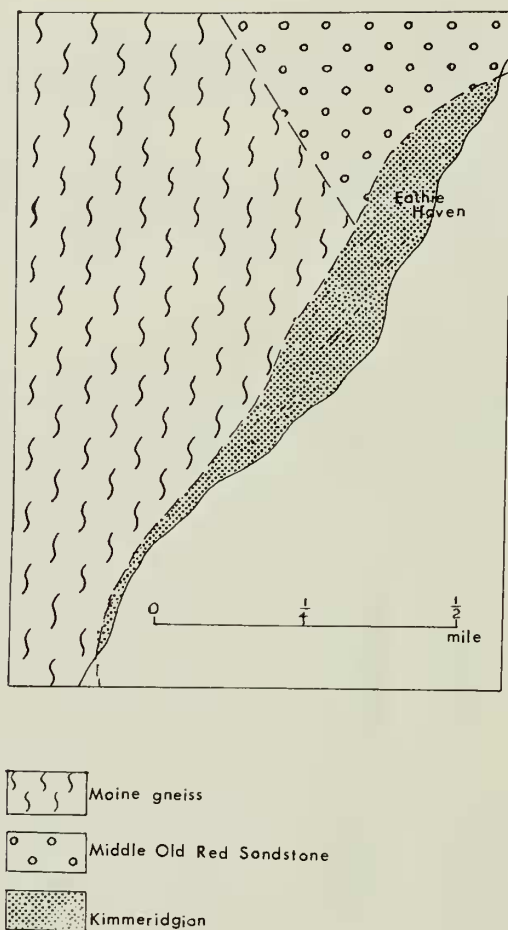


FIG. 2. A. Sketch map showing the geology around Eathie, Cromarty (after Waterston, 1952).

Ager and Wallace, 1966a, b). Eight samples were studied, seven of which (obtained from the basal formations, which are the equivalent of the Baylei Zone in Dorset) were described in a previous paper (Gitmez, 1970). In addition, one was obtained from the Subplanites Zone *sensu* Arkell, here considered probably equivalent to the Scitulus Zone of Cope, 1967.

CC 453—clay, light grey in colour (N7), from Argiles de la Crèche, north of Cap de la Crèche. No microfossils were recovered.

(8) Normandy:

Only the lower Kimmeridgian is represented in Normandy: it appears beneath the unconformable Cretaceous and comprises clays and limestones with ammonites



indicative of the Mutabilis, Cymodoce and Baylei Zones. Two samples were studied, one from the Baylei Zone (described by Gitmez, 1970), the other from the Cymodoce Zone:

BN 179—Marls, light olive grey in colour (5 Y 6/1), Benerville, Normandy.

(9) Le Havre, Seine Inférieure:

On the shore at Cap de la Hève, clays and limestones of Kimmeridgian age are exposed, beneath the Cretaceous unconformity, at the foot of the cliffs. Three

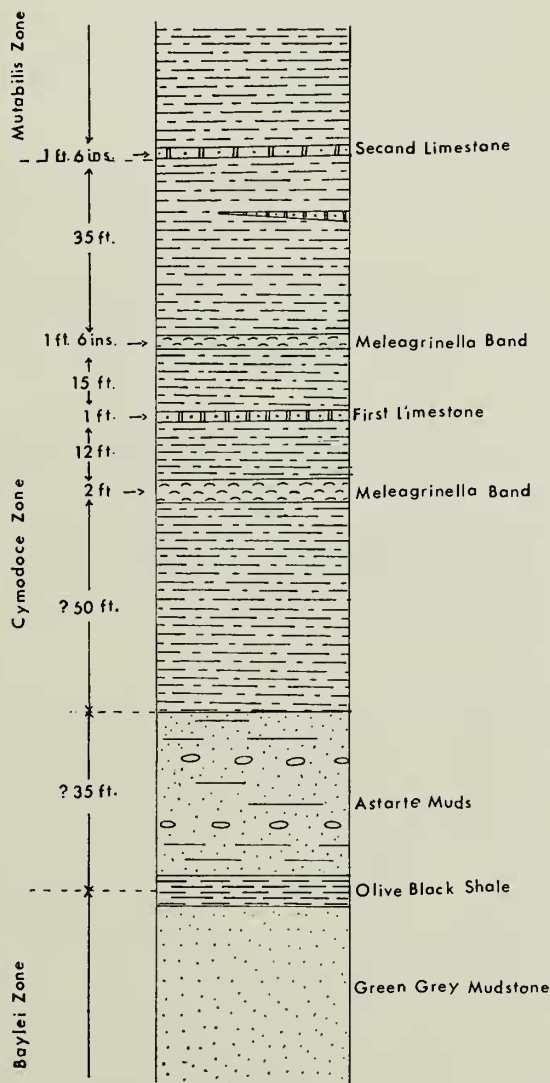


FIG. 2. B. The section of the strata at Eathie, Cromarty (after Waterston, 1952).

samples were studied: two of these, from the Baylei Zone, have already been described (Gitmez 1970); the third sample was from the Mutabilis Zone.

HF 395—Marls, light olive grey in colour (5 Y 6/1), from the Marnes à ammonites, Cap de la Hève.

(10) Lorraine:

In the east of the Paris basin, the Cretaceous usually rests on the Oxfordian; occasionally, however, some Lower Kimmeridgian rocks are still present below the unconformity. Only one sample was obtained from Lorraine:

LF 368—Marl, yellowish grey-light olive grey in colour (5 Y 7/1), collected from the Cymodoce Zone, about 2 ft above the Calcaires à Astartes. Roadside, about 1 km east of Gondrecourt. [This sample contains very few microfossils.]

(11) Mont Crussol (Rhône Valley):

The Jurassic rocks of Mont Crussol comprise a continuous and well-exposed, dominantly calcareous sequence from Upper Bathonian to Tithonian (see Karvé-Corvinus, 1966). The Middle and Lower Tithonian (which is equivalent to the Upper and Middle Kimmeridgian *sensu anglico*) is represented by limestones of various sorts. Thick limestones form the Kimmeridgian stage in its restricted, Continental acceptation (the Tenuilobatus, Pseudomutabilis and Beckeri Zones representing the Lower and Middle Kimmeridgian, *sensu anglico*).

Eight samples were examined, the first sample yielding very few microfossils, the others none at all;

1. MR 547—Limestone, yellowish grey-light olive grey in colour (5 Y 7/1), from the lower boundary of the Platynota Zone (?Baylei Zone), small quarry above the west side of the Ravin d'Enfer.

2. MR 548—Limestone, light grey in colour (N7), from the lower part of the Ataxioceras Zone (Cymodoce-Mutabilis Zones), same locality.

3. MR 549—Limestone, very light grey in colour (N8), from the top of the Ataxioceras Zone, same locality.

4. MR 550—Limestone, pinkish grey in colour (5 YR 8/1), from the *Idoceras balderum* Bed, same locality.

5. MR 552—Limestone, yellowish grey in colour (5 Y 8/1), from the fossil band at the base of Pseudomutabilis Zone (i.e. Autissiodorensis Zone), ridge top above the Carrière Mallet.

6. MR 553—Limestone, yellowish grey-light olive grey in colour (5 Y 7/1), from the Pseudomutabilis Zone, ridge top.

7. MR 554—Limestone, light olive grey in colour (5 Y 6/1), from the lower boundary of the Beckeri Zone (i.e. Autissiodorensis-Elegans Zones), ridge top.

8. MR 555—Limestone, pinkish grey in colour (7 YR 8/1), from the Beckeri Zone, near the summit of the ridge.

(12) The Jura Mountains (Southern French Jura):

As the original type locality for Alexander von Humboldt's "Jurassic", this region is of particular interest. The most important recent work has (rather unexpectedly) been done by English geologists (see Ager and Evamy, 1963). The sequence is again predominantly calcareous and exposure is intermittent but adequate. Three

samples from the Oignon Beds and two samples from the Virieu Limestone were examined:

1. OF 485—Limestone (a well-bedded calcilutite), yellowish grey in colour (5 Y 8/1), from the road side, Montard d'Oignon (type locality). Mutabilis Zone.

2. OF 486—Limestone, yellowish-light olive grey in colour (5 Y 7/1), from the top of the Oignon Beds, beneath a pisolite; roadside west of Lac du Chavoley. Mutabilis Zone.

3. OF 487—Pisolitic limestone, yellowish grey in colour (5 Y 8/1), from the junction of Oignon Beds and Bedded Virieu, 2 km north of St. Germain-de-Joux (Mutabilis Zone). [This sample contains few microfossils.]

4. BV 488—Limestone, greenish grey in colour (5 GY 6/1), from the base of Bedded Virieu (Lower Kimmeridgian), calcilutite above pisolite.

5. MV 489—Limestone, pinkish grey in colour (5 YR 8/1), from the Massive Virieu (?Upper Kimmeridgian), 200 yards west of Virieu-le-Grand (type locality). [The sample yielded very few microfossils.]

### III. SYSTEMATIC SECTION

#### Class *DINOPHYCEAE* Pascher

#### Sub-class *DINOFEROPHYCIDAE* Bergh

#### Order *DINOPHYCIALES* Lindemann

#### Cyst-Family *FROMEACEAE* Sarjeant & Downie, 1966

#### Genus *CHYTROEISPHAERIDIA* Sarjeant, 1962

emend. Downie, Evitt & Sarjeant, 1963

#### *Chytroeisphaeridia chytrooides* Sarjeant, 1962b

#### Plate I, figure 2

1962b *Leiosphaeridia* (*Chytroeisphaeridia*) *chytrooides* Sarjeant, 493-4, pl. 70, figs 13, 16, text-figs 11-12, tables 2-3.

1963 *Chytroeisphaeridia chytrooides* (Sarjeant); Downie, Evitt & Sarjeant, 9.

1964a *Leiosphaeridia chytrooides* Sarjeant; Sarjeant, table 3.

1964 *Chytroeisphaeridia chytrooides* (Sarjeant); Downie & Sarjeant, 103.

1967b *C. chytrooides* (Sarjeant); Sarjeant, table III.

1968 *C. chytrooides* (Sarjeant); Sarjeant, pl. III, fig. 10, table 2B.

1970 *C. chytrooides* (Sarjeant); Gitmez, pl. 14, fig. 5, table 4.

1970 *C. chytrooides* (Sarjeant); Gocht, 152, pl. 34, figs 20-24.

FIGURED SPECIMEN: I.G.S. slide PK102A: Sample WB 2, Kimmeridge Clay. H.M. Geological Survey Borehole, Warlingham, Surrey, at 2959 feet 5 in. depth. Lower Kimmeridgian (Mutabilis Zone).

DIMENSIONS: Figured specimen: length (apex lacking) 45 $\mu$ , breadth 48 $\mu$ . Range of the English specimens: length (apex lacking) 12-72 $\mu$ , breadth 18-80 $\mu$ , measured specimens 1029 in number. Range of the Scottish specimens (40 specimens measured); length (apex lacking) 20-50 $\mu$ , breadth 22-75 $\mu$ . 161 specimens from French assem-

blages were measured: length (apex lacking) 16–62 $\mu$ , breadth 22–65 $\mu$ . There is no significant difference between the size of specimens from different zones in the Kimmeridgian or between English, Scottish and French specimens. The Kimmeridgian specimens exhibit a somewhat wider dimensional range than do the Oxfordian specimens; diameters of the latter, as quoted by Sarjeant (1962b), are 30–60 $\mu$ .

OBSERVED RANGE: Kimmeridgian (Baylei to Pallasioides).

TOTAL KNOWN RANGE: ?Lower Bathonian: certainly Callovian (Mariae) to Kimmeridgian (Pallasioides).

REMARKS: This species occurs in moderate abundance in all Kimmeridgian assemblages from England, Scotland and France, being most abundant in the Lower Kimmeridgian, numerically somewhat reduced in the Upper Kimmeridgian (Pallasioides Zone).

*Chytroeisphaeridia mantelli* sp. nov.

Plate 1, figures 3–4; Plate 12, figure 3

DERIVATION OF THE NAME: Named in honour of Gideon Algernon Mantell, pioneer of the study of microplankton.

DIAGNOSIS: Shell subspherical to elongate. The periphragm is coarsely granular and bears an irregular scatter of tubercles and of low knobs, giving it a somewhat warty appearance. An apical archaeopyle is present, with slits extending posteriorly along presumed reflected sutures, producing a ragged appearance. The operculum most often remains attached to the ventral side of the shell.

HOLOTYPE: I.G.S. slide PK116, Sample WB 13, Kimmeridge Clay, H.M. Geological Survey Borehole, Warlingham, Surrey, at 2684 ft 2 in. depth. Lower Kimmeridgian (Autissiodorensis Zone).

PARATYPE A: I.G.S. Slide PK114, Sample WB 13.

PARATYPE B: BM(NH) slide V.56338 (1) sample CH 231, from 22 ft below the Blackstone, Clavells Hard, Dorset. Middle Kimmeridgian (Wheatleyensis Zone).

DIMENSIONS: Holotype: overall length 65 $\mu$ , breadth 60 $\mu$ . Paratype A: overall length (apex lacking) 60 $\mu$ , breadth 65 $\mu$ . Paratype B: overall length (apex lacking) 65 $\mu$ , breadth 70 $\mu$ . Range of Lower Kimmeridgian specimens: length (apex lacking) 25–75 $\mu$ , breadth 30–65 $\mu$ , measured specimens 12 in number. Range of Middle Kimmeridgian specimens: length (apex lacking) 40–80 $\mu$ , breadth 50–75 $\mu$ , measured specimens 16 in number. Range of Upper Kimmeridgian specimens: length (apex lacking) 23–70 $\mu$ , breadth 28–75 $\mu$ , measured specimens 12 in number.

According to these measurements, the species attained its largest size in the Middle Kimmeridgian.

DESCRIPTION: The thick shell wall is apparently composed of two layers: the inner layer thin, the outer layer making up almost the entire wall thickness. The ornamentation of the periphragm is of three types: coarse granules, small irregularly

formed lumps (verrucae) and rounded tubercles, irregularly scattered. A tabulation is indicated only by the slits; there is no suggestion of a cingulum. The sulcal notch was seen only in specimens in which the operculum was completely lost; it was not perceptible in specimens with the operculum still attached. This is considered to indicate that when the operculum is present, it is attached to the ventral side of the cyst.

REMARKS: *C. mantelli* differs from previously described species of the genus in its relatively thick wall, the ornamentation of the periphragm and the form of its apical archaeopyle. The most similar species is *C. euteiches* Davey (1969), from the Cenomanian; but the shell wall of this new species is not so thick as in *C. euteiches* ( $2.3\mu$  as quoted by Davey). Although *C. euteiches* has an apical archaeopyle, it is angular in outline and generally narrower, whereas in *C. mantelli* the archaeopyle is characteristically wide, with deep slits passing posteriorly from its margin. (Davey mentioned that the apical archaeopyle of *C. euteiches* also has small slits extending posteriorly from the margin.)

This new species, in its surface ornamentation and wall structure, also shows a broad accord with the diagnosis of *Tenua* as emended by Sarjeant (1968b). Since cingulum and sulcus are not indicated and since, although the cyst wall shows a considerable ornament, spines are not present, it was allocated to the genus *Chytroeisphaeridia*. However, it should be noted that the form of the archaeopyle is closer to that of *Tenua* than to that of typical species of *Chytroeisphaeridia*. This species is thus intermediate in morphology between the genera *Chytroeisphaeridia* and *Tenua*.

*C. mantelli* was recorded from all zones of the Kimmeridge Clay; it was more abundant in the Middle Kimmeridgian (Eudoxus to Elegans Zones) than in the other subdivisions of the Kimmeridgian. Thirty-seven specimens from England and five specimens from France were examined; it was not observed in the Scottish assemblages.

### *Chytroeisphaeridia pococki* Sarjeant, 1968

Plate 1, figure 5

1965 *Chytroeisphaeridia* sp. Sarjeant, pl. 1, fig. 13.

1968 *Chytroeisphaeridia pococki* Sarjeant, 230, pl. 3, fig. 9.

1970 *C. pococki* Sarjeant; Gitmez, pl. 9, fig. 7, pl. 10, fig. 3, table 4.

FIGURED SPECIMEN: BM(NH) Slide V.53961(3). Sample SC 444, from Great Ouse River Board Pit, Stretham, Cambridgeshire. Lower Kimmeridgian (Baylei Zone).

DIMENSIONS: Figured specimen: length (apex lacking)  $18\mu$ , breadth  $22\mu$ . Range of Lower Kimmeridgian specimens: length (apex lacking)  $18-85\mu$ , breadth  $22-78\mu$ , measured specimens 178 in number.

Range of Middle Kimmeridgian specimens: length (apex lacking)  $35-75\mu$ , breadth  $35-80\mu$ , measured specimens 113 in number.

Range of Upper Kimmeridgian specimens: length (apex lacking)  $28-80\mu$ , breadth  $35-80\mu$ , measured specimens 61 in number.



There is no difference in dimensions between the English, Scottish and French specimens. Lower and Middle Kimmeridgian specimens are of comparable dimensions to those of the Oxfordian holotype (dimensions, as quoted by Sarjeant; length [apex lacking]  $45\mu$ , breadth  $55\mu$ ).

OBSERVED RANGE: Kimmeridgian (Baylei to Pallasioides).

TOTAL KNOWN RANGE: Callovian (Lamberti to Mariae) and Kimmeridgian (Baylei to Pallasioides) of Europe; Upper Jurassic of Canada.

REMARKS: *C. pococki* is present in the Kimmeridgian assemblages from England, Scotland and France: although present at all levels, it was found to be most abundant in the Lower and Middle Kimmeridgian, being especially common in the Warlingham borehole samples.

Genus **FROMEA** Cookson & Eisenack, 1958

*Fromea warlinghamensis* sp. nov.

Plate 1, figures 6, 8; Plate 9, figures 5-6

DERIVATION OF THE NAME: Named after the type occurrence in the Warlingham borehole, Surrey.

DIAGNOSIS: Cyst broadly ovoidal to almost spherical, with a relatively thick wall. Archeopyle apical, subhexagonal to almost circular; a rather rounded projection, not always observable, appears to be a sulcal tongue. The shell surface is densely and coarsely granular. A cingulum is indicated by indentations at the margins; less frequently, it is traceable across the surface.

HOLOTYPE: I.G.S. slide PK115, Sample WB 13, Kimmeridge Clay, H.M. Geological Survey borehole, Warlingham, Surrey, at 2684 ft 3 in. depth. Lower Kimmeridgian (Autissiodorensis Zone). PARATYPES (a) BM(NH) slide V.56339(2), sample CH 231, slide V.56339(2) Kimmeridge Clay 22 ft below the Black Stone (Wheatleyensis Zone), Clavell's Hard, Dorset. (b) BM(NH) slide V.56340(1), sample LO 353, top of Kimmeridge Clay (Pallasioides Zone), Littleworth, Oxfordshire.

DIMENSIONS: Holotype: length (apex lacking)  $47.3\mu$ , breadth  $40.5\mu$ . Paratype (a): length (apex lacking)  $81.5\mu$ , breadth  $79.5\mu$ . Paratype (b): length (apex lacking)  $71\mu$ , breadth  $65\mu$ . Range of specimens observed (25 in number); length (apex lacking)  $42-95\mu$ , breadth  $40-88\mu$ .

DESCRIPTION: The pronounced original sphericity characteristic of this species results in a variety of structures produced by compression; paratype (a) in particular, shows an irregular series of bulges. The granules are of variable size and are characteristically circular; the distinctly polygonal granules on the outbulges on paratype (a) probably result from pressure by mineral grains. The wall appears to be composed of a single layer: it may be as much as  $2-3\mu$  in thickness.

OBSERVED RANGE: Kimmeridgian (Autissiodorensis to Pallasioides Zones).

REMARKS: This new species is distinguished from *Fromea amphora*, the only other species to date placed in this genus, by its much more spherical shape and coarsely



granular surface. The known range of the latter species is Barremian to Albian (Cookson and Eisenack, 1958): the stratigraphic hiatus between the type species and this Upper Jurassic species may well be removed by future studies.

Genus *TENUA* Eisenack, 1958c emend. Sarjeant, 1968

*Tenua capitata* (Cookson & Eisenack, 1960b) comb. nov.

Plate 1, figures 11-12

1960b *Hystrichosphaeridium capitatum* Cookson & Eisenack, 252. pl. 39 fig. 9.

1964 *H. capitatum* Cookson & Eisenack; Sarjeant, table 3.

1964 *H. capitatum* Cookson & Eisenack; Downie & Sarjeant, 120.

1970 *Tenua* cf. *capitata* (Cookson & Eisenack); Gitmez. pl. 10, fig. 4. table 4.

DESCRIPTION: Cyst spherical to elongate, with an apical archaeopyle and rounded antapex, bearing processes whose length sometimes reaches to one-third of the shell breadth and which number around fifty. The processes are hollow, capitate or briefly bifurcate, their distribution appearing random.

FIGURED SPECIMEN: BM(NH) slide V.56341(1) sample HF 185, from the Exogyra Marls, c. 1 m above the Upper Hard Band, Cap de la Hève, Le Havre. Lower Kimmeridgian (Baylei Zone).

DIMENSIONS: Range of the English specimens: length (apex lacking) 30-65 $\mu$ , breadth 22-50 $\mu$  (7 specimens measured). Range of the French specimens: length (apex lacking) 30-40 $\mu$ , breadth 22-33 $\mu$  (2 specimens measured). 3 specimens from the Scottish assemblages were recorded and measured: length (apex lacking) 30-58 $\mu$ , breadth 30-58 $\mu$ . Overall range of process length (all localities) 3-10 $\mu$ . There is not much difference between these dimensions and the dimensions of the Australian specimens quoted by Cookson and Eisenack (length 64-66 $\mu$ , breadth 28-44 $\mu$ , process length 8 $\mu$ ).

OBSERVED RANGE: Kimmeridgian (Baylei to Mutabilis).

TOTAL KNOWN RANGE: Jurassic (Oxfordian to Kimmeridgian).

REMARKS: This species, under the name of *Hystrichosphaeridium capitatum*, has previously been recorded from the Oxfordian to Kimmeridgian of Australia by Cookson and Eisenack. It is transferred to the genus *Tenua* on the basis of shell outline, the presence of an apical archaeopyle, and the form and number of the processes. The processes do not clearly reflect any tabulation.

Well-preserved specimens were observed in moderate numbers in samples from the Lower Kimmeridgian only; nine specimens from the Baylei Zone of England and three specimens from that zone in France; three specimens from the Cymodoce Zone of Scotland; and two specimens from the Mutabilis Zone of England were recorded.

These specimens are similar to that figured by Cookson and Eisenack. Although the number of the processes appears greater than in the Australian specimens, it was not possible to make precise comparisons since the number of processes was not mentioned by Cookson and Eisenack.

*Tenua echinata* sp. nov.

Plate 1, figures 1, 9

1969 *Tenua* sp. Gitmez, 245-6 pl. 8, fig. 3, text-fig. 3, table 4.

DERIVATION OF THE NAME: Latin, *echinatus*, spiny, prickly; referring to the spiny surface of the shell.

DIAGNOSIS: Cyst spherical, subspherical or broadly ovoidal, covered with spines and looking like a prickly ball. Spines very short, broad-based and conical, uniformly distributed over the whole surface, over 200 in number. There is no indication of tabulation, cingulum or sulcus. Archaeopyle usually present, apical in position; the operculum usually remains attached on one side but is sometimes completely lost.

HOLOTYPE: BM(NH) slide V.52796(1). Sample OM 131, from the base of the Kimmeridge Clay, *Liostrea delta* Bed, Osmington Mills, Dorset. Lower Kimmeridgian (Baylei Zone).

PARATYPE: I.G.S. slide PK.119, sample WB 16, from H.M. Geological Survey borehole, Warlingham, Surrey, at 2610 ft depth. Middle Kimmeridgian (Scitulus Zone).

DIMENSIONS: Holotype: overall length  $50\mu$ , breadth  $50\mu$ ; length without apex  $43\mu$ ; length of the spines  $2\mu$ .

Paratype: overall length  $72\mu$ , breadth  $60\mu$ ; length of the spines  $2.5\mu$ .

Overall range of the English specimens (15 specimens measured): length  $45-90\mu$ , breadth  $40-80\mu$ , length without apex (3 specimens were observed without apex)  $43-60\mu$ ; length of the spines  $1.5-2.5\mu$ .

Dimensions of the single French specimen encountered: length (apex lacking)  $38\mu$ , breadth  $40\mu$ ; length of spines  $2\mu$ .

DESCRIPTION: The shell surface is smooth. The apex is typically detached in archaeopyle formation. The margin of the archaeopyle is roughly polygonal, with tears extending from the angles along the presumed lines of a reflected tabulation. When the operculum remains attached on one side, this side is probably the ventral side. The spines appear to be solid.

OBSERVED RANGE: Kimmeridgian (Baylei to Pallasiodides Zones). Not recorded to date from the Mutabilis, Autissiodorensis and Elegans Zones.

REMARKS: This new species of *Tenua* differs from previously described species of the genus in its characteristic shape and in the nature of its spines. It is an infrequent species: 15 specimens from English assemblages and only a single specimen from France were recorded.

*Tenua* sp.

Plate 1, figures 7, 10

1970 *Chytroeisphaeridia pococki* Gitmez: pl. 9, fig. 8, table 4.

DESCRIPTION: Shell spheroidal to broadly ovoidal, densely granular. The shell

wall may or may not be composed of two layers: if the wall is indeed bipartite, then both layers are thin. The outer wall (periphragm?) bears numerous spines whose character is seen clearly only at the margins, especially around the antapex. The spines are slender and short: the relative length of particular spines is, however, highly variable, median spines being consistently shorter than those of the antapical region. At their tips, the spines are most often knobbed, capitate or briefly bifurcate. The cingulum is faintly indicated by two parallel lines in the equatorial region. An apical archaeopyle is developed, with a scalloped margin suggesting partial reflection of a tabulation.

FIGURED SPECIMEN: BM(NH) slide V.53619(1). Sample SS 627, from 100 ft above the second dolerite sill, Staffin Bay, Skye. Lower Kimmeridgian (Baylei Zone).

DIMENSIONS: Figured specimen: length (apex lacking):  $50\mu$ , breadth  $55\mu$ , spine length  $2-3\mu$ .

REMARKS: This specimen was mentioned earlier as *Chytroeisphaeridia pococki* by one of the authors (Gitmez, 1970), but later examination by high power phase contrast objective showed the presence of spines and other details which made it clear that this specimen is different from *C. pococki*. The observation was based on a single, fairly well preserved specimen. It is generally similar to *Tenua verrucosa* Sarjeant and *Tenua villersense* Sarjeant; the shape of the spines compares closely with those of *T. villersense*, but they are very short, as in *T. verrucosa*. This may be a representative of an undescribed species intermediate between *T. verrucosa* and *T. villersense*.

### Cyst-Family GONYAULACYSTACEAE Sarjeant & Downie, 1966

Genus **CRYPTARCHAEODINIUM** Deflandre, 1939b emend. Gitmez, 1970

*Cryptarchaeodinium calcaratum* Deflandre, 1939b emend. Gitmez, 1970

1939b *Cryptarchaeodinium calcaratum* Deflandre, 145, pl. 6, fig. 6.

1941a *C. calcaratum* Deflandre; Deflandre, 19, pl. 5, figs. 7-9; text-figs 9-10.

1962 *C. calcaratum* Deflandre; G. & M. Deflandre, fiche 1908.

1964 *C. calcaratum* Deflandre; Downie & Sarjeant, 104.

1964 *C. calcaratum* Deflandre; Eisenack, 153-4.

1964 *C. calcaratum* Deflandre; Sarjeant, table 2.

1965 *C. calcaratum* Deflandre; Górka, 303, pl. 2, figs 3-5, table 1.

1967b *C. calcaratum* Deflandre; Sarjeant, table IV.

1970 *C. calcaratum* Deflandre; Gitmez, 246-8 pl. 1, figs 1-2, text-fig. 4, table 4.

OBSERVED RANGE: Kimmeridgian (Baylei and Rotunda Zones).

TOTAL KNOWN RANGE: ?Oxfordian to Kimmeridgian (Rotunda).

REMARKS: Deflandre first observed this species in the Kimmeridgian assemblages from Orbagnoux (1939); a fuller diagnosis was given later (1941). In 1965, Górka recorded this species for the first time from Poland, in sediments considered to be of Oxfordian age. She observed the archaeopyle formation (by loss of plate 3') and determined a tabulation similar to that of the Kimmeridgian specimens, except that

she mentioned the presence of a second antapical plate: this plate (2''') was never observed in the Kimmeridgian specimens. According to the measurements quoted by Górka, the Polish specimens from the Oxfordian are larger than the English and French Kimmeridgian specimens, with longer sutural spines. The attribution of these Polish specimens to the species *C. calcaratum* must, all in all, be considered very doubtful.

*Cryptarchaeodinium* cf. *calcaratum*

Plate 2, figure 3; text-figure 3

DESCRIPTION: Shell spherical, with a small, blunt apical horn and rounded, dome-shaped antapex. Tabulation: 4', 6'', 6c, 7''', 2p, ?1pv and 1'''. Apical plates small; plates 1' and 3' form the apical horn. The precingular plates are more or less constant in shape and size, the boundary between plates 5'' and 6'' not being clear. Cingulum equatorial, a laevorotatory spiral; cingular plates 3c and 4c are the largest and occupy the dorsal side. The postcingular plates are of variable shape and size: plates 1''', 2''', and 7''' are relatively small and triangular, plate 4''' (the largest) is more or less square. Two posterior intercalary plates, 1p and 2p, are present and placed on either side of plate 1pv: the boundary between 1p and 1pv was not clear. Plate 2p is very small. The single antapical plate (1''') is convex and its greatest portion is positioned on the dorsal side of the cyst: this does not seem to be the result of distortion in compression. The sulcus is short, being very wide on the epitract but narrowing on the hypotract. On the plate boundaries, crests of irregularly spinous character rise up: some crest spines are briefly bifurcate. The shell surface is minutely granular. An archaeopyle was not observed.

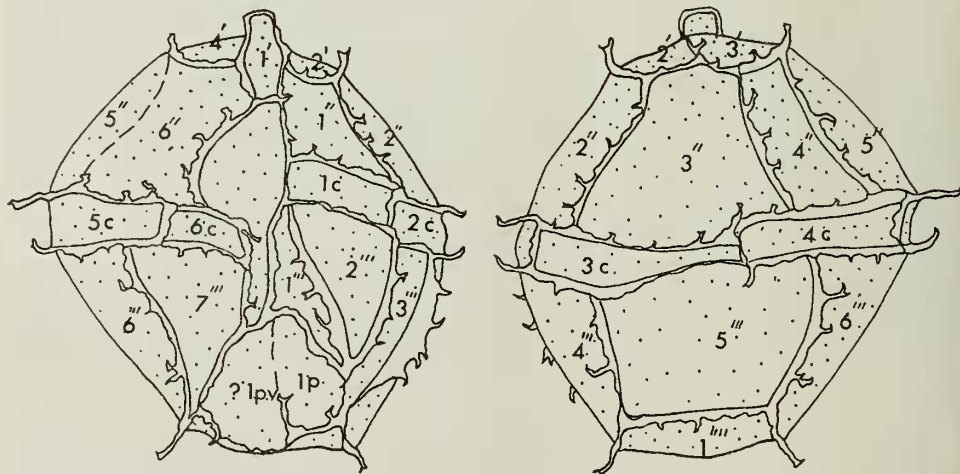


FIG. 3. *Cryptarchaeodinium* cf. *calcaratum* Deflandre. General appearance, showing the tabulation: left, in ventral view; right, in dorsal view. BM(NH) slide V.56342 (1).  
× c. 1400.



FIGURED SPECIMEN: BM(NH) slide V.56342(1). Sample CS 421, from the first Meleagrinea Band of Eathie, Cromarty. Lower Kimmeridgian (Cymodoce Zone).

DIMENSIONS: Overall length 40–50 $\mu$ , breadth 35–50 $\mu$ , horn length 5–6 $\mu$ , length of the spines on the sutures 4–6 $\mu$ . Two specimens were measured.

REMARKS: Two specimens observed, one from the Lower Kimmeridgian (Cymodoce Zone) of Scotland and one from the Upper Kimmeridgian (Pectinatus Zone) of Dorset, are similar to *C. calcaratum* except in their possession of an apical horn and in slight differences in the shape of the plates on the hypotract.

Genus **GONYAULACYSTA** Deflandre, 1964 emend. Sarjeant, 1969

*Gonyaulacysta cauda* sp. nov.

Plate 2, figures 1–2, 4–5

1969 *Gonyaulacysta* sp. B Gitmez, pl. 6, fig. 3, text-fig. 14, table 4.

DERIVATION OF THE NAME: Latin, *cauda*, tail, appendage; in reference to the antapical spines.

DIAGNOSIS: The broadly ovoidal cyst possesses a poorly developed apical horn with long spines arising from its tip. Tabulation: 4', 1a, 6'', 6c, 6''', 1p, 1pv and 1'''''. Spiny crests separate the plates. The single antapical plate is characteristically surrounded by long (nearly three times longer than the other sutural spines), thin, simple spines. Cingulum helicoid, laevorotatory; sulcus moderately broad, extending on both epitract and hypotract to the same length. Surface densely granular. Precingular archaeopyle, if present, formed by loss of plate 3''.

HOLOTYPE: BM(NH) slide V.53965(2) from the sample CC 447, Argiles de Moulin Wibert of Cap de la Crèche, Boulonnais, France. Lower Kimmeridgian (Baylei Zone).

PARATYPE: BM(NH) slide V.56343(1). Sample HC 243, from c. 100 ft below Rotunda Nodules, base of Hounstout Cliff, Dorset. Upper Kimmeridgian (Pectinatus Zone).

DIMENSIONS: Holotype: overall length 78 $\mu$ , breadth 50 $\mu$ , apical horn length 8 $\mu$ ; length of the sutural processes 3–5 $\mu$ , antapical processes 8 $\mu$ ; breadth of the cingulum 3–5 $\mu$ .

Paratype: length 80 $\mu$ , breadth 65 $\mu$ , apical horn length 12 $\mu$ , antapical processes length 10 $\mu$ .

A third specimen could not be measured because of its poor preservation.

DESCRIPTION: The slightly helicoid, laevorotatory cingulum of moderate breadth, divides the cyst into two unequal parts. The conical epitract terminates in a poorly developed apical horn, the hypotract is dome-shaped. The epitract is larger than the hypotract, almost two-thirds of the shell length. Apical plate 1' is elongate, its anterior and posterior ends being narrow; together with plate 3', it forms the apical horn. Plate 2' is quite large; 4' is the smallest of the apical plates. The single anterior intercalary plate 1a is large; as a result plate

6'' is reduced. The precingular plate 1'' is long and narrow; plates 2'', 3'', 4'' and 5'' are large. One of the specimens observed has a precingular archaeopyle, formed by loss of plate 3''. Six postcingular plates occupy the hypotract, together with the single antapical plate and the posterior plates. Plate 1''' is quadrate and as small as the adjacent sulcal plate; all the other postcingular plates are relatively large. A crescent-shaped plate, 1pv, separates the sulcus from antapical plate 1'''. The boundary surrounding the antapical plate 1''' bears longer spines than the other sutural spines. All the sutural spines are simple, solid, thin, threadlike.

REMARKS: This new species is rare, only three specimens being recorded from the following samples: CC 447, RB 219, HC 243 (The first two are from the Baylei Zone, the last from the Pectinatus Zone). It has not been observed in the Middle Kimmeridgian. Two specimens were well preserved, with tabulation and mode of archaeopyle formation easily determinable, but the third was badly preserved. With their long spines distributed like tassels around the antapex, these specimens are different from all previously described proximate dinoflagellate cysts.

*Gonyaulacysta* cf. *giuseppei* (Morgenroth, 1966) Sarjeant, 1969

Plate 3, figures 3-4, text-figure 4

DESCRIPTION: Cyst subspherical to globular, with the tabulation 4', 6'', 6c, 6''', 1p and 1'''. The cingulum is strongly helicoid, laevorotatory, dividing the cyst into two equal parts: the epitract ends in a short apical horn, the hypotract has a conical aspect with very convex antapex. The apical plates combine to form the

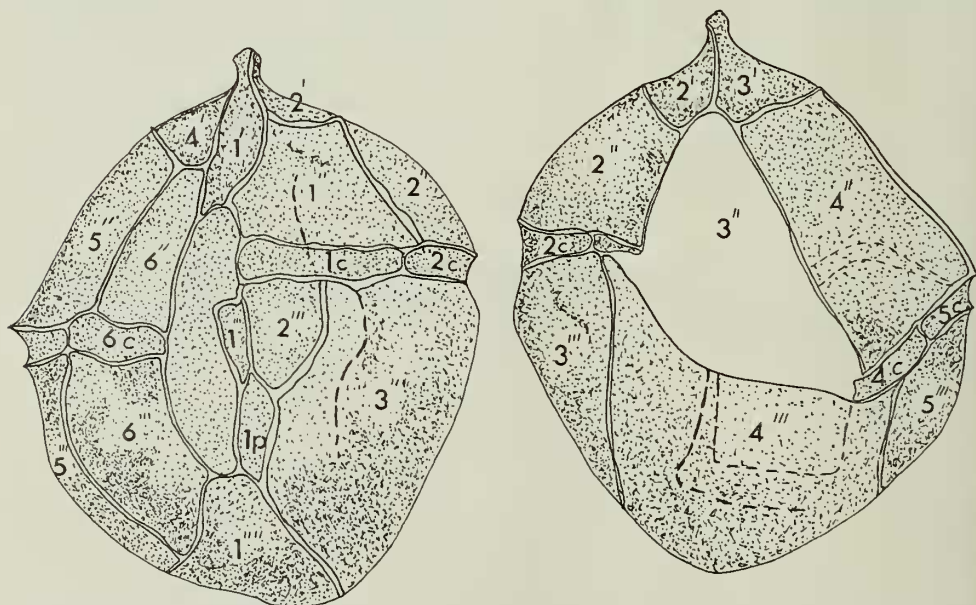


FIG. 4. *Gonyaulacysta* cf. *giuseppei* (Morgenroth). Showing tabulation and archaeopyle: left, in ventral view; right, in dorsal view. BM(NH) slide V.56344.  $\times$  c. 1010.



apical horn. The precingular plates, except plate 6'', are quite large. Plate 3'' is subtriangular in shape and lost in archaeopyle formation, together with some parts of the cingulum (plate 3, figure 4). The postcingular plates are of variable size and shape: plates 1''' and 2''' are both reduced to accommodate the long posterior intercalary plate 1p. Plates 3''' and 4''' are the largest of all the plates. A single convex plate occupies the antapex. The sulcus is broad, extending between the apex and the antapex. The surface of the shell is granular. Crests on the plate boundaries are low and membranous.

FIGURED SPECIMEN: BM(NH) slide V.56344(1). Sample CC 448 from Calcaires de Moulin Wibert, south side of Cap de la Crèche, Boulonnais. Lower Kimmeridgian (Baylei Zone).

DIMENSIONS: Figured specimen: overall length 78 $\mu$ , breadth 62 $\mu$ , length of apical horn 6 $\mu$ . Range of the observed specimens: overall length 65–78 $\mu$ , breadth 58–62 $\mu$ , horn length 5–6 $\mu$ . (Measured specimens 4 in number.) Morgenroth gave the following dimensions for *G. giuseppei* (Eocene): length 67–87 $\mu$ , breadth 67–78 $\mu$ , horn length 6–8 $\mu$ . The specimens from the Kimmeridgian are thus slightly smaller than the true *G. giuseppei*.

REMARKS: Four specimens from the Lower Kimmeridgian assemblages of the Baylei and Mutabilis Zones (one from France, three from England) are closely similar to *G. giuseppei*, recorded from the Lower Eocene of Germany by Morgenroth (1966). The only major difference is in the shape of the precingular archaeopyle; *G. giuseppei* has a very large, markedly polygonal archaeopyle, but in the Kimmeridgian specimens observed, the archaeopyle is somewhat smaller and tapers so markedly towards the apex that it appears almost triangular. Since the big stratigraphical gap makes it improbable that these specimens are conspecific with *G. giuseppei*, they are compared with, rather than attributed to that species.

### *Gonyaulacysta globata* sp. nov.

Plate 3, figures 1–2; text-figures 5 A–B

DERIVATION OF THE NAME: Latin, *globus*, ball, sphere, in reference to the overall shape of the cyst.

DIAGNOSIS: A proximate cyst, subspherical to broadly ovoidal with a strong apical horn. The sutural crests are low, generally well defined, and reflect the tabulation 4', 1a, 6'', 6c, 6''', ?1p and 1'''''. Cingulum moderately narrow, helicoid, laevorotatory, dividing the theca unequally, the epitract being longer than the hypotract. The sulcus is broad. The surface of the shell is densely granular. A precingular archaeopyle, formed by loss of plate 3'', is developed in some instances.

HOLOTYPE: I.G.S. slide PK.122, Sample WB 20, H.M. Geological Survey Borehole, Warlingham, Surrey at 2510 ft depth. Middle Kimmeridgian (Wheatleyensis Zone).

PARATYPE: BM(NH) slide V.56345. Sample FN 236, from the White Stone Band,  $\frac{1}{4}$  m west of Freshwater Steps, Dorset. Middle Kimmeridgian (boundary of Pectinatus-Hudlestoni Zones).

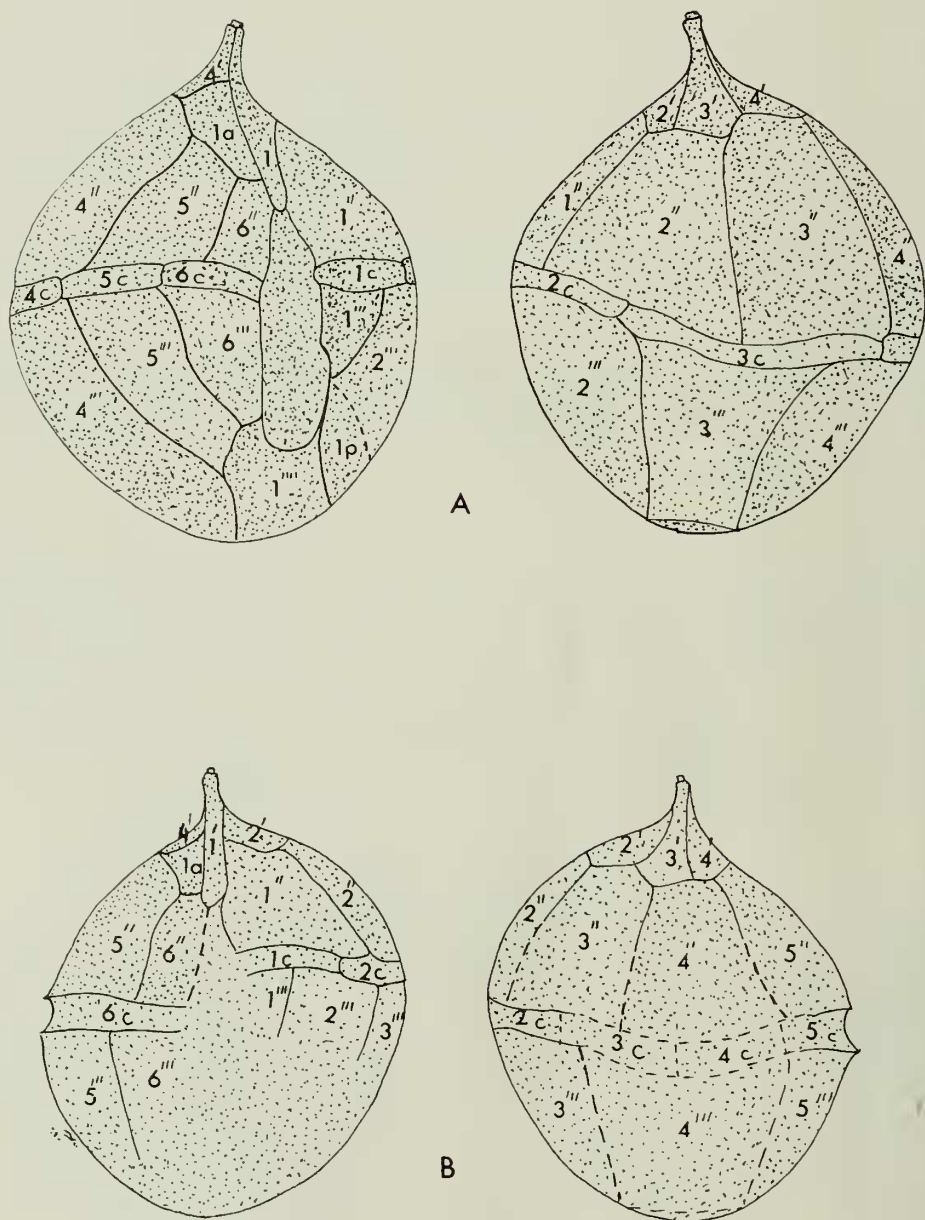


FIG. 5. *Gonyaulacysta globtaa* sp. nov. A. Holotype: left, in ventral view; right, in dorsal view. I.G.S. slide PK 122.  $\times$  c.800. B. Paratype: showing the epitracial tabulation: left, in ventral view; right, in dorsal view. BM(NH) slide V.56345.  $\times$  c.655.

**DIMENSIONS:** Holotype: overall length  $90\mu$ , breadth  $68\mu$ , apical horn length  $11\mu$ . Paratype: overall length  $92\mu$ , breadth  $75\mu$ , horn length  $12\mu$ . Range of the observed specimens: overall length  $85$ – $92\mu$ , breadth  $62$ – $75\mu$ , horn length  $11$ – $12\mu$ . (Four specimens were measured.)

**DESCRIPTION:** The cyst is globular, relatively thin-walled. Four apical plates combine to form the slender horn. Plate  $1'$  is narrow and elongate, the other apical plates are approximately polygonal but with an apical prolongation. A single anterior intercalary plate is present and quite large, apical plate  $4'$  and precingular plates  $5''$  and  $6''$  being correspondingly reduced. The four other precingular plates are large. The cingular plates are poorly defined, but appear to number six.

The hypotract is dome-shaped, composed of large reflected plates; plate  $4'''$  is the largest of all. Plate  $1'''$  is greatly reduced; plates  $5'''$  and  $6'''$  are relatively small. The boundary between the plates  $1p$  and  $2'''$  was not confirmed. The single antapical plate,  $1'''$ , is also large.

The sulcus is narrow in its anterior portion, broadening to contact with the cingulum and thenceforward remaining of constant breadth in its posterior portion. It is relatively short and extends to the antapex.

In one specimen only, a precingular archaeopyle was seen, formed by loss of plate  $3''$ .

**OBSERVED RANGE:** Kimmeridgian (Wheatleyensis-Pectinatus Zones).

**REMARKS:** This species is extremely infrequent: of four specimens encountered, the holotype and paratype only are moderately well preserved, the other two being folded, crushed and severely damaged.

In its combination of overall morphology and tabulation *G. globata* differs from previously described species of *Gonyaulacysta*. The most closely similar species is *G. nuciformis*, but *G. globata* differs in having a relatively thin cyst wall and dissimilar ventral antapical tabulation.

***Gonyaulacysta longicornis* (Downie, 1957) Sarjeant, 1969, emend.**

Plate 2, figure 6; Plate 4, figure 1; text-figure 6

- 1957 *Gonyaulax longicornis* Downie, 420, pl. 20, fig. 8; text-figs 2a–b; table 1.
- 1962 *G. longicornis* Downie; G. & M. Deflandre, fiche 1830.
- 1964 *G. longicornis* Downie; Downie & Sarjeant, 115.
- 1964 *G. longicornis* Downie; Sarjeant, table 2.
- 1964 *G. longicornis* Downie; Eisenack, 371–2.
- 1966 *Gonyaulacysta longicornis* (Downie); Sarjeant, *nomen nudum*, 131.
- 1967b *G. longicornis* (Downie); Sarjeant, *nomen nudum*, table 1.
- 1967b *Gonyaulax longicornis* Downie; Vozzhennikova, table 12.
- 1969 *Gonyaulacysta longicornis* (Downie); Sarjeant, 10.
- 1970 *G. longicornis* (Downie); Gitmez, table 4.

**EMENDED DIAGNOSIS:** This species of *Gonyaulacysta* is characterized by a very long apical horn (not less than one-third of the whole length). Tabulation:  $4'$ ,  $6''$ ,  $6c$ ,  $6'''$ ,  $1p$  and  $1'''$ . Cingulum slightly helicoid, dividing the cyst unequally: the epitract being longer than the hypotract. On the sutures, short, roughly denticulate



DESCRIPTION: The thin-walled shell is roughly polygonal in shape, with a long apical horn and conical hypotract. The apical horn, with its solid tip, is formed by four long apical plates; plate 1' is elongate, the others are almost triangular. The apical plates, together with six precingular plates, make up the epitract; this is separated from the hypotract by a narrow cingulum and is always longer than the hypotract. Six cingular plates of variable size occupy the cingulum. The sulcus extends onto the epitract and hypotract, between the apex and the antapex. Six postcingular plates of variable shape and size are present: plate 1''' is reduced to accommodate the posterior intercalary plate, 1p; plates 2'', 3''' and 5''' are more or less uniform in size and plate 4''' is the largest of all the plates.

OBSERVED RANGE: Kimmeridgian (Baylei to Pallasioides Zones) [See discussion below].

TOTAL KNOWN RANGE: Kimmeridgian (Baylei to Pallasioides Zones).

REMARKS: *G. longicornis* has been known hitherto only from the Upper Kimmeridgian of England. Though the specimens in the French and English assemblages were generally badly preserved, it was possible to determine the tabulation and the mode of archaeopyle formation. This species was doubtfully included in the genus *Gonyaulacysta* by Sarjeant (1969), in the absence of knowledge of the type of archaeopyle; the new observations confirm this reallocation.

The observed specimens are closely similar to Downie's figured specimen, but show slight differences in tabulation. The apical horn is not developed from plate 1' only, as figured by Downie; instead, it is made up of four apical plates. The posterior intercalary plate was not shown on the figure of the holotype, but was observed in all specimens encountered.

*G. longicornis* is similar to *Pareodinia nuda* (Downie) in the shape of the apical horn and general appearance; but no tabulation has been yet determined for *P. nuda* and an intercalary archaeopyle was considered by Sarjeant (1967a pp. 254) to be developed in the latter species.

In England, *G. longicornis* was found in most horizons of the Kimmeridgian from Aulacostephanus to Pallasioides, but it was absent from the lowest zones and the Rotunda Zone. In France, in contrast, it was recorded only from the Baylei Zone. Thirteen specimens from France and forty-six specimens from England were recorded.

***Gonyaulacysta* cf. *mamillifera* (Deflandre, 1939b) Sarjeant, 1969**

Plate 4, figure 7; text-figure 7

DESCRIPTION: Relatively large, globular shell, broadly ovoidal to subspherical in shape. The more or less equatorial cingulum is slightly helicoid and divides the cyst into two equal parts; the epitract terminates in a mammelon form (in two of the observed specimens, this was well-developed, but the third one has a feebly-developed apical prominence); the hypotract is rounded. Tabulation: 4', 6'', 6c, 6''', 1p, 1'''. Plate boundaries are marked by low membraneous crests. The sulcus is long, extending further on the epitract than on the hypotract; it narrows



towards the apex. The shell wall is thin, its surface densely granular and punctate. A precingular archaeopyle is present, formed by the loss of plate 3".

FIGURED SPECIMEN: I.G.S. slide PK.130, Sample WB 29, from H.M. Geological Survey Borehole, Warlingham, Surrey, at 2285 ft 7 in. depth. Upper Kimmeridgian (Rotunda Zone).

DIMENSIONS: Figured specimen: length 92 $\mu$ , breadth 80 $\mu$ . Range: length 76–92 $\mu$ , breadth 60–80 $\mu$ , measured specimens 3 in number. (Holotype dimensions: length 92 $\mu$ , breadth 84 $\mu$ , as given by Deflandre).

REMARKS: *G. mamillifera* has only been previously recorded from the Kimmeridgian of France. In this investigation, three specimens probably attributable to this species were observed: one from the Baylei Zone of France and two from the Rotunda Zone of England. In their general aspect they are closely similar to *G. mamillifera*; however, there are differences in the reconstructed tabulation and the ornamentation of the sutures. In the observed specimens the sutures are in the form of membranous crests, not spinose, as described by Deflandre. The tabulation is generally similar, but the shapes of postcingular plates 1''' and 2''' are different. Comparison between the apical plates of this form and *G. mamillifera* was not possible, because Deflandre was unable to determine the apical tabulation. Allocation to this species must, therefore, be provisional only.

### *Gonyaulacysta nuciformis* (Deflandre) Sarjeant, 1969

Plate 3, figure 5; text-figure 8

- 1938 *Palaeoperidinium nuciforme* Deflandre, 180, pl. 8, figs 4–6.
- 1962a *P. nuciforme* Deflandre; Sarjeant, pl. 1, fig. 8; tables 3–4.
- 1962b *Gonyaulax nuciformis* (Deflandre); Sarjeant, 482–3, pl. 69, fig. 6; text-fig. 4; tables 2–3.
- 1964 *G. nuciformis* (Deflandre); Downie & Sarjeant, 115.
- 1964 *G. nuciformis* (Deflandre); Sarjeant, table 2.
- 1964 *Palaeoperidinium nuciformis* Deflandre; Eisenack, 609.
- 1965 *Palaeoperidinium nuciformoides* Górka, 300–1, pl. 2, figs 1–2; table 1.
- 1966 *P. nuciformoides* (Deflandre) G. & M. Deflandre, fiche 3030.
- 1966 ?*Gonyaulacysta nuciformis* (Deflandre); Sarjeant, *nomen nudum* 132.
- 1967b *Gonyaulax nuciformis* (Deflandre); Vozzhennikova, table 11.
- 1967b *Gonyaulacysta nuciformis* (Deflandre); Sarjeant, *nomen nudum*, table 1.
- 1968b *G. nuciformis* (Deflandre); Sarjeant, *nomen nudum*, 227, pl. 3, fig. 4; table 2A.
- 1969 *G. nuciformis* (Deflandre); Beju, *nomen nudum*, 10, pl. 3, fig. 1; table 1.
- 1969 *G. nuciformis* (Deflandre); Sarjeant, 10.
- 1970 *G. nuciformis* (Deflandre); Gitmez, 3, pl. 6, fig. 1; table 4.

DESCRIPTION: The shell is ovoidal to spherical, with the tabulation 4', 1a, 6'', 6c, 6''', 1p, 1pv and 1'''. The epitract and hypotract are more or less equal in size; the epitract ends with an apical horn of variable length, the hypotract is dome-shaped with rounded antapex. The cingulum is helicoid, laevorotatory. The sulcus is broad and extends onto both the epitract and hypotract. The shell is densely granular and relatively thick; because of this, determination of the tabulation is difficult. A precingular archaeopyle was developed by some specimens, formed by loss of plate 3".



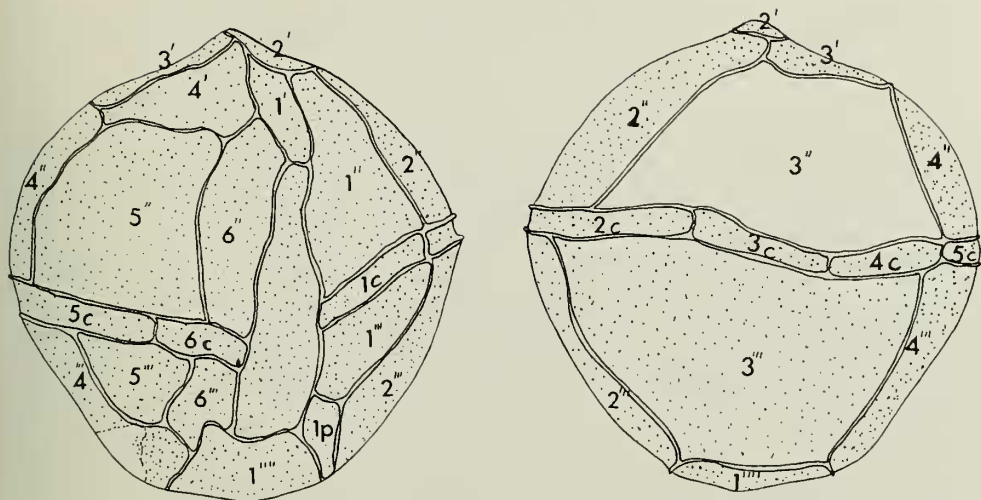


FIG. 7. *Gonyaulacysta cf. mamillifera* (Deflandre). Showing the tabulation: left, in ventral view; right, in dorsal view. I.G.S. slide PK 130.  $\times$  c.772.

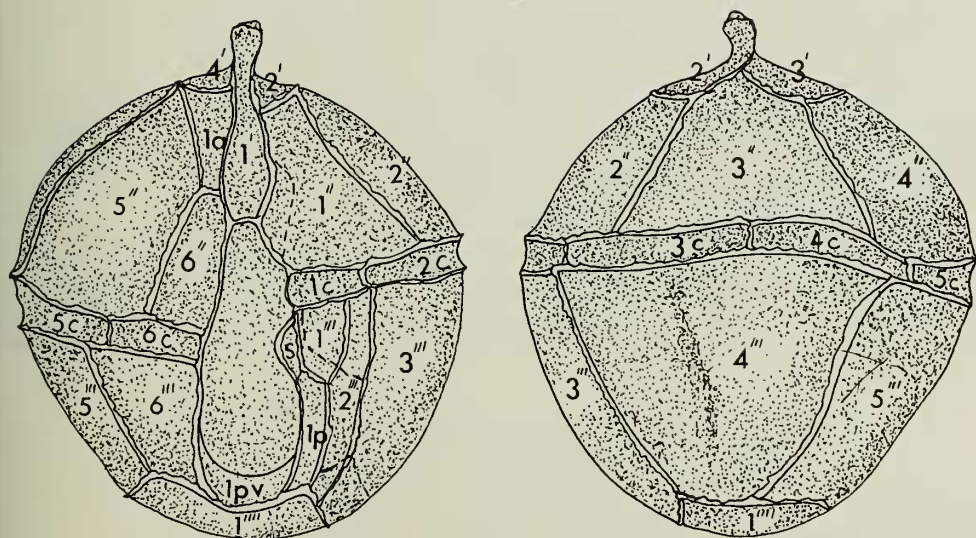


FIG. 8. *Gonyaulacysta nuciformis* (Deflandre). Tabulation: left, in ventral view; right, in dorsal view. Specimen I.G.S. slide PK 109.  $\times$  c.1112.

FIGURED SPECIMEN: I.G.S. slide PK.109, Sample WB 7, from H.M. Geological Survey Borehole, Warlingham, Surrey, at 2834 ft 7 in. depth. Lower Kimmeridgian (Eudoxus Zone).

DIMENSIONS: Figured specimen: overall length  $70\mu$ , breadth  $60\mu$ , horn length  $9\mu$ .

Range of the Lower Kimmeridgian specimens (61 specimens were measured): overall length  $43\text{--}118\mu$ , breadth  $40\text{--}85\mu$ , horn length  $4\text{--}12\mu$ .

Range of the Middle Kimmeridgian specimens (28 specimens were measured): overall length  $68\text{--}105\mu$ , breadth  $60\text{--}85\mu$ , horn length  $5\text{--}12\mu$ .

Range of the Upper Kimmeridgian specimens (18 specimens were measured): overall length  $65\text{--}102\mu$ , breadth  $55\text{--}85\mu$ , horn length  $6\text{--}12\mu$ .

The following dimensions were quoted by Deflandre for the Oxfordian specimens from France: overall length  $60\text{--}65\mu$ , breadth  $47\text{--}53\mu$  (approximately). Dimensions of the Callovian specimens from England, as given by Sarjeant: overall length  $56\text{--}58\mu$ , breadth  $50\text{--}64\mu$ . Górka gave the following dimensions for Polish Upper Jurassic specimens: overall length  $38\text{--}54\mu$ , breadth  $40\text{--}44\mu$ . Dimensions of the Roumanian specimens (Oxfordian to Kimmeridgian) are given by Beju as overall length  $62\text{--}78\mu$ , breadth  $60\text{--}78\mu$ . The Polish specimens are thus smaller than the others and the Roumanian specimens are more spherical. The Kimmeridgian specimens are larger than the specimens from lower stages.

OBSERVED RANGE: Kimmeridgian (Baylei to Pallasioides).

TOTAL KNOWN RANGE: Upper Callovian (Lamberti) to Upper Kimmeridgian (Pallasioides).

REMARKS: *G. nuciformis* was first recorded from the Upper Jurassic of France by Deflandre (1938). Subsequently, this Upper Jurassic species has been observed in several assemblages from Western Europe, and the geographic range has been extended by its observation from the Callovian to Kimmeridgian of Roumania by Beju (1969). It is generally present in moderate abundance in Kimmeridgian assemblages; however, it was not observed in the Middle and Upper Kimmeridgian of France. Also there is a progressive reduction in the number of specimens in the English assemblages through the Upper Kimmeridgian.

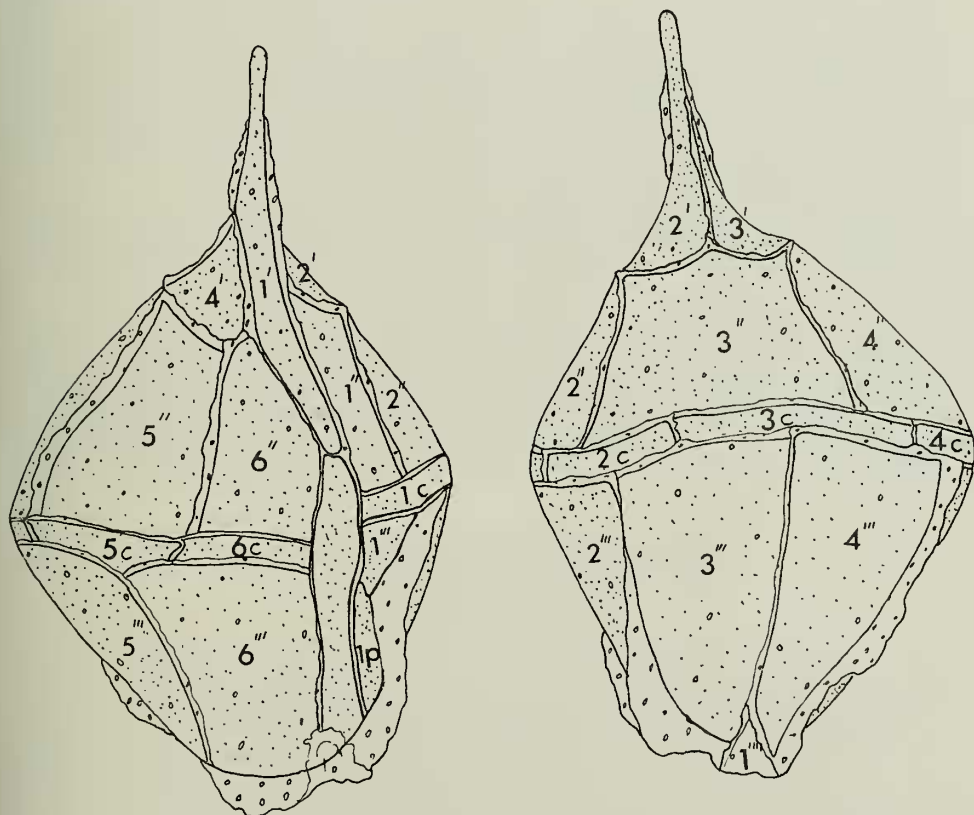
The combination *Gonyaulacysta nuciformis* in Beju (1969), although proposed in correct form, was not validly published since a pre-print distributed at a meeting does not constitute effective publication (cf. 'International Code of Botanical Nomenclature', Art. 29). The combination is, therefore, correctly attributed to Sarjeant (1969).

### *Gonyaulacysta perforans* (Cookson & Eisenack) Sarjeant, 1969

Plate 4, figure 6; text-figure 9

- 1958 *Gonyaulax perforans* Cookson & Eisenack, 30, pl. 2, figs 1-4, 7-8; text-figs 8-9.
- 1961 *G. perforans* Cookson & Eisenack; Alberti, 6, pl. 11, figs 4-6; tables a-c.
- 1962 *G. perforans* Cookson & Eisenack; G. & M. Deflandre, fiches 1849-1852.
- 1963 *G. perforans* Cookson & Eisenack; Baltes, 584, pl. 4, figs 1-6, table 1.
- 1964 *G. perforans* Cookson & Eisenack; Downie & Sarjeant, 115.

- DESCRIPTION: The cyst is elongate, with a long apical horn. The epitract and hypotract are separated by the helicoid, laevorotatory cingulum and are more or less equal in size. Tabulation: 4', 6'', 6''', 1p and 1'''''. Plate boundaries are demarcated by membranous, delicate porate crests, which are well developed around the apex and the antapex. The sulcus is long and narrow, extending from apex to antapex. The shell wall is thin, the surface granular and occasionally perforate. An archaeopyle was rarely observed; when developed, it forms by the loss of plate 3''.



C

FIGURED SPECIMEN: I.G.S. slide PK.131, Sample WB 29, from H.M. Geological Survey Borehole, Warlingham, Surrey, at 2285 ft 7 in. depth. Upper Kimmeridgian (Rotunda Zone).

DIMENSIONS: Figured specimen: overall length  $108\mu$ , breadth  $70\mu$ , horn length  $33\mu$ . Range of the Middle Kimmeridgian specimens (7 specimens measured): overall length  $73$ – $100\mu$ , breadth  $54$ – $73\mu$ , horn length  $16$ – $18\mu$ . 15 specimens measured from the Upper Kimmeridgian: overall length  $80$ – $110\mu$ , breadth  $52$ – $75\mu$ , horn length  $12$ – $40\mu$ . Cookson and Eisenack gave the following dimensions for the specimens from New Guinea: length  $136$ – $168\mu$ , breadth  $93$ – $109\mu$ . Dimensions of the specimens from Germany are quoted by Alberti as length  $130$ – $145\mu$  and breadth  $81$ – $103\mu$ . The British and French Middle Kimmeridgian specimens are thus smaller than the Upper Kimmeridgian specimens, but both are smaller than the New Guinea and German specimens.

OBSERVED RANGE: Kimmeridgian (Wheatleyensis to Pallasioides).

TOTAL KNOWN RANGE: Upper Jurassic to Lower Cretaceous (Albian).

REMARKS: *G. perforans* was originally recorded from the Upper Jurassic of New Guinea by Cookson and Eisenack; later Alberti observed it in the Barremian assemblages from Germany and Balteş recorded it from the Albian of Roumania. It is recorded in English assemblages for the first time. The observed specimens are similar to those figured by Cookson and Eisenack, except for small differences in tabulation and in the length of the apical horn.

Although the New Guinea and German specimens are larger than the Kimmeridgian specimens, from the figures they seem to have a proportionately smaller horn. (Since the horn length was not specified, it is possible to deduce this only from the figures.)

Cookson and Eisenack did not mention the presence of apical plate 4', but in their figure a boundary is shown between the plates 3' on the ventral side and 3' on the dorsal side; therefore, the plate on the ventral side should be the fourth apical plate, as observed in the Kimmeridgian specimens. Similarly the elongate plate which they figure below the postcingular plate 1''' should be the posterior intercalary plate, 1p.

### *Gonyaulacysta systremmatos* sp. nov.

#### Plate 5, figures 7–8

1970 *Gonyaulacysta* sp. C. Gitmez, 265–7, pl. 4, figures 10–11, text-fig. 15, table 4.

DERIVATION OF NAME: Greek, *systremmatos*, anything consolidated, generally a ball or round object; in reference to the ball-like shape of the shell.

DIAGNOSIS: Thick-walled shell, almost spherical, with a moderately long apical horn. Tabulation: 4', 1a, 6'', 6–7c, 7''', 1p, 1pv, 1'''. The plate boundaries are demarcated by delicate crests of variable height. The cingulum is helicoid, laevorotatory; the sulcus is short and broadens posteriorly. The surface is densely granular. A precingular archeopyle, formed by loss of plate 3'', is generally developed.



HOLOTYPE: BM(NH) slide V.53966(1), from the sample CC 447, Argiles de Moulin Wibert, Cap de la Crèche, Boulonnais, France. Lower Kimmeridgian (Baylei Zone).

DIMENSIONS: Holotype: overall length  $68\mu$ , breadth  $62\mu$ , horn length  $8\mu$ , height of the crests  $4-5\mu$ . Range of the observed specimens: overall length  $66-78\mu$ , breadth  $60-65\mu$ , horn length  $7-16\mu$ ; measured specimens 5 in number.

DESCRIPTION: The helicoid, laevorotatory cingulum divides the cyst unequally. The epitract is somewhat longer than the hypotract; both are more or less dome-shaped. The number of the cingular plates is hesitantly mentioned, because the character of the small plate beside 6c is doubtful; it may be either a small cingular plate or a short sulcal plate.

Four apical plates make up the apex, plate 1' occupying the anterior prolongation of the sulcus. Plates 2' and 3' are small; plate 4' is almost as large as plate 1'. The single, small anterior intercalary plate is placed between the plates 4' and 6''. The precingular plates are generally large, plate 6'' being of reduced size because of the presence of intercalary plate 1a.

The postcingular plates are of variable size and shape: plate 1''' is very small; plate 2''' is also reduced and does not have a boundary with the antapical plate. Plates 3''', 4''', 5''' and 6''' are relatively large; plate 7''' is in contrast reduced, having nearly the same size as plate 2'''. The quite broad intercalary plate, 1pv, separates the sulcus from the single antapical plate 1''''.

REMARKS: This is an infrequent species, six specimens being encountered, all from the Baylei Zone of France. They were badly preserved, being somewhat crushed, folded or covered by debris; the holotype was the best oriented for study. In its general form, this new species of *Gonyaulacysta* differs from all described species. The most closely comparable species is *G. palla* Sarjeant, which has a similarly spherical shape and comparable tabulation; but *G. systemmatus* differs in its apical horn, sutural crests, absence of plate 1a, and presence of plate 1pv. In the possession of a seventh postcingular plate, it is comparable with *G. fetchamensis* and *G. ehrenbergii*, but it is markedly different in overall morphology from both these species.

### *Gonyaulacysta* sp. A

#### Plate 9, figures 1-2

1970 *Gonyaulacysta* sp. A. Gitmez, 263-4, pl. 3, fig. 3, text-fig. 13.

FIGURED SPECIMEN: BM(NH) slide V.56347(2), Kimmeridge Clay (Pectinatus Zone) 60 ft above Freshwater Steps Stone Band, Egmont Bight, Dorset.

DIMENSIONS: Figured specimen: overall length  $103\mu$ , length of apical horn  $32\mu$ , overall breadth  $66.5\mu$ , length of crest spines c.  $1.5-2\mu$ .

REMARKS: This form was originally described on the basis of two specimens from the lowest Kimmeridge Clay (Baylei Zone) of Normandy. The discovery of a third specimen at a higher horizon is thus of interest: its dimensions are markedly larger



than those of the specimens described earlier (overall length  $65\mu$ , breadth  $42\mu$ ) but its proportions are similar. Yet further specimens of this type must be located before nomenclatural proposals can justly be made.

*Gonyaulacysta* sp. B

Plate 4, figures 2-3, text-figure 10

DESCRIPTION: Only one specimen of this species has so far been observed. It possesses a subspherical cyst, bearing a moderately well developed apical horn. The strongly helicoid, laevorotatory cingulum divides the cyst into two more or less equal parts: the hypotract is somewhat flattened at the antapex. The sulcus is sigmoidal and narrow. Tabulation: 4', 6'', 6c, 5''', 1p, ?1pv and 1''''.

The apical plates 1' and 4' are small and elongate; together with plates 2' and 3', they form the apical horn. The precingular plates are quite large. Plate 3'' is lost in archaeopyle formation. On the hypotract, crests demarcate five postcingular plates. Plate 1''' and 5''' are reduced because of the presence of posterior plates, but the other postcingular plates are large. A single antapical plate occupies the antapex.

The wall is moderately thin, its surface finely granular and in part tuberculate. Crests on the plate boundaries are delicate; the denticulation is very deep, virtually giving the crests the appearance of a row of bifid spines.

FIGURED SPECIMEN: I.G.S. slide PK.117, Slide WB 15, from H.M. Geological Survey Borehole, Warlingham, Surrey, at 2635 ft 3 in. depth. Middle Kimmeridgian (Elegans Zone).

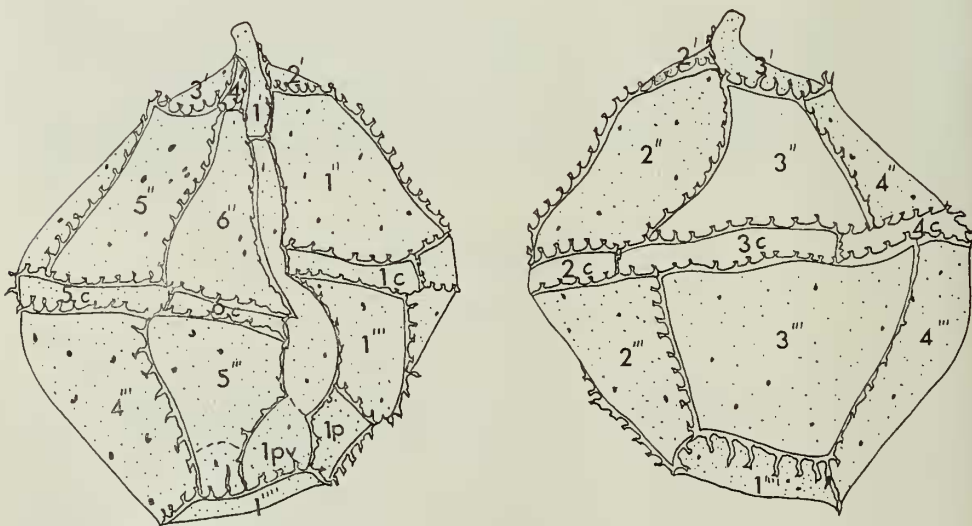


FIG. 10. *Gonyaulacysta* sp. B. Tabulation: left, in ventral view; right in dorsal view. Specimen I.G.S. slide PK 117.  $\times c.1351$ .

DIMENSIONS: Overall length  $48\mu$ , breadth  $45\mu$ , horn length  $5\mu$ , sutures  $3\text{--}5\mu$  high.

REMARKS: In its general morphological features and sutural characteristics, this species may be distinguished from all previously described species of *Gonyaulacysta*. The shape of the shell and crests is most comparable to *G. serrata* Cookson & Eisenack (1958) suggesting a relationship between the two species, but the form of the apical horn is different; since a tabulation could not be determined for *G. serrata*, a detailed comparison of these two species is impossible.

*Gonyaulacysta* sp. C

Plate 6, figures 1–2, text-figure 11

DESCRIPTION: The cyst is subspherical, bearing a short, tapering apical horn. The thickness of the wall is uneven because of irregularly distributed granules. The sutural crests are in the form of low ridges giving rise occasionally to delicate membranes: they indicate a reflected tabulation of  $4'$ ,  $1a$ ,  $6''$ ,  $6c$ ,  $6'''$ ,  $?1pv$ ,  $1''''$ . Four apical plates together form the horn; plate  $1'$  is elongate in shape. The precingular plates, except plate  $6''$ , are of almost uniform shape and size; plate  $6''$  is reduced to accommodate the intercalary plate  $1a$ .

Six cingular plates make up the slightly helicoid, laevorotatory cingulum: plate  $6c$  is very small, the others are relatively large. The ends of the cingulum are widely separated by a very broad sulcus, which further widens in its posterior portion.

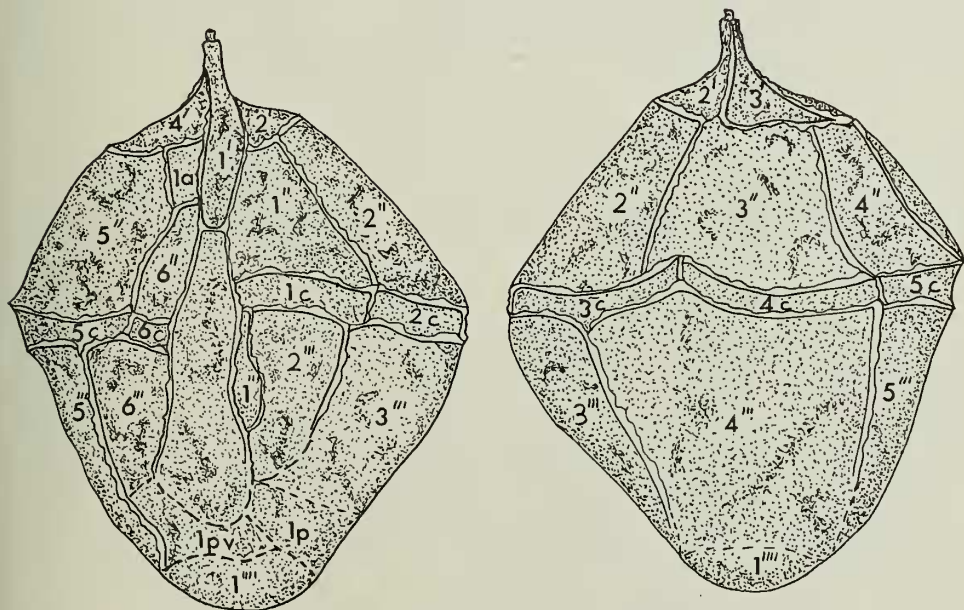


FIG. 11. *Gonyaulacysta* sp. C. Tabulation: left, in ventral view; right, in dorsal view. Specimen I.G.S. slide PK 118.  $\times c.984$ .

(The antapical end of the sulcus and the plate boundaries near to the antapex were not very clear because of bad preservation of this part of the cyst.) The first post-cingular plate, 1''', is narrow, elongate and small. Plate 4''' appears the largest of the post-cingular plates. No archaeopyle was observed in this specimen.

FIGURED SPECIMEN: I.G.S. slide PK.118, Sample WB 16, from H.M. Geological Survey Borehole, Warlingham, Surrey, at 2510 ft depth. Middle Kimmeridgian (Scitulus Zone).

DIMENSIONS: Overall length 77 $\mu$ , breadth 60 $\mu$ , apical horn length 8 $\mu$ .

REMARKS: Only one specimen has so far been observed. It is distinguished from all previously described species in its overall morphological features; it is possibly a new species, but further specimens are needed to decide this.

### *Gonyaulacysta* sp. D

Plate 6, figures 4-5; text-figure 12

DESCRIPTION: A specimen with an almost spherical cyst and short, blunt, tapering apical horn. The shell wall is composed of two layers, periphragm and endophragm, which are of the same thickness; the periphragm is coarsely granular. The apical horn is formed of both shell layers. Tabulation: 4', 1a, 6'', 6c, 6''', 1p and 1'''. Plate 1' is elongate and occupies the anterior prolongation of the sulcus. Plates 2' and 3' are large; plate 4' is slightly reduced to accommodate the anterior intercalary plate, 1a. Four apical plates together make up the apical horn. Plate 1a is quite large; because of this, plate 6'' is reduced. The other precingular plates are of more or less similar shape and size. The cingulum is of moderate breadth,

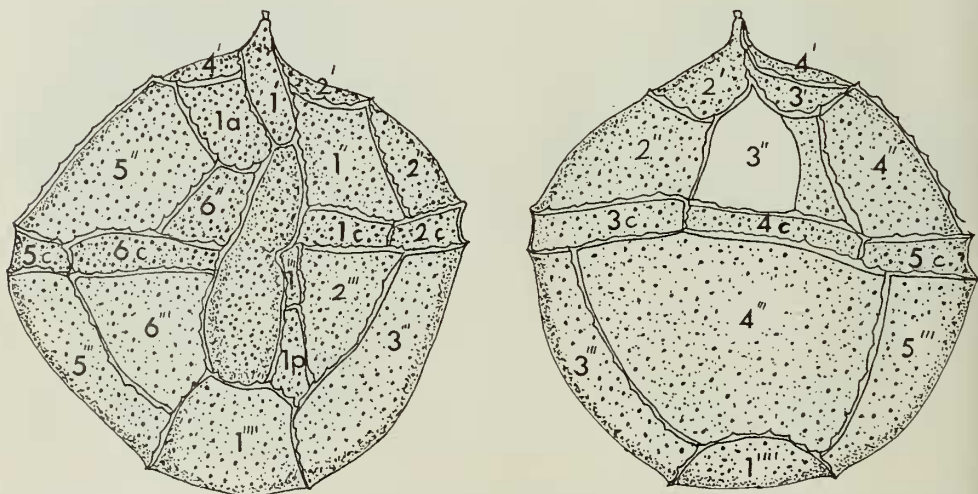


FIG. 12. *Gonyaulacysta* sp. D. Tabulation and archaeopyle formation, Plate 3'' is partially lost in the archaeopyle formation. Specimen BM(NH) slide V.56346 (4).  $\times$  c.1035.

possessing six cingular plates: plate 1c is smaller and broader than the other cingular plates. Postcingular plate 1''' is very small and gives the appearance of hanging onto one corner of the cingulum. Plate 2''' and 6''' are relatively small; plates 3'', 4''' and 5''' are large. An elongate posterior intercalary plate (1p) is placed below plate 1'''. The single antapical plate, 1''', is large and convex. The broad sulcus extends between the apex and antapex.

Plate boundaries are demarcated by low crests and generally well defined. A precingular archaeopyle was seen in some specimens; it forms by loss of plate 3'' (in the figured specimen, plate 3'' is partially detached).

FIGURED SPECIMEN: BM(NH) slide V.56346(4). Sample LO 353, from the Littleworth Quarry, Oxfordshire. Upper Kimmeridgian (Pallasioides Zone).

DIMENSIONS: Figured specimen: overall length 65 $\mu$ , breadth 60 $\mu$ , horn length 5 $\mu$ . Range: overall length 65–80 $\mu$ , breadth 60–75 $\mu$ , horn length 4–7 $\mu$ . Measured specimens 5 in number; 3 other observed specimens could not be measured because of bad preservation.

REMARKS: This unnamed species of *Gonyaulacysta* differs from all described species in its general aspect and peculiar apical horn. The most comparable species is *G. palla* Sarjeant, both species having similarly spherical cysts and tapering apical horns. In *Gonyaulacysta* sp. C, the apical horn is broad based and short and its tip appears conical: although *G. palla* has a tapering horn, it is slender and relatively long. The number of the plates on the epitract is the same for both species, but plate 4' is not placed at the top of the horn as in *G. palla*. The hypotracial plates (especially plates 1'', 2''' and 1p) appear similar in shape to those of *G. palla*, but their number is different: *G. palla* has seven postcingular plates, whereas this species has six. The crests of *G. palla* are spiny. The similarity between these two species is thus only in the overall shape.

Eight specimens, all from the same quarry in Littleworth, were recorded; unfortunately, all the specimens encountered are somewhat crushed, folded or covered by debris, which makes them difficult to examine in detail. The figured specimen was the best oriented for study. It may be a new species, but needs further, better preserved specimens for typification.

### *Gonyaulacysta* sp. E

Plate 6, figure 9; text-figure 13

DESCRIPTION: Only one moderately well preserved specimen of this type was observed, in the Lower Kimmeridgian assemblages from the Warlingham Borehole. It possesses an elongate cyst, with conical epitract and dome-shaped hypotract, thus looking rather like a pear. The apical horn is slender and tapering. The wall is densely granular. Plate boundaries are well defined by moderately high membraneous crests. Tabulation: 4', 1a, 6'', 6c, 6''', 1p, 1pv and 1'''. Plate 1' is characteristically long and broad, extending down almost two-thirds of the epitract. Plates 2' and 3' are similar to each other; plate 4' is greatly reduced because of the anterior intercalary plate 1a. For the same reason, plates 5'' and 6'' are also reduced.



The other precingular plates are quite large. The six postcingular plates are of variable shape and size. Plate 1''' is small and triangular; plates 2''' and 6''' are moderately large; plates 3'', 4'' and 5'' very large, together almost occupying the whole dorsal side of the hypotract. A single plate occupies the antapex. The posterior intercalary plate (1p) is elongate. A crescent-shaped plate, 1pv, separates the sulcus from the antapical plate 1'''. The cingulum is deep, formed by 6 cingular plates, of which 5c and 6c are quite small; it is almost circular and divides the cyst into two unequal parts, with the epitract twice as long as the hypotract. The sulcus is very short and broad. An archaeopyle was not observed.

FIGURED SPECIMEN: I.G.S. slide PK.1113. Sample WB 13, from H.M. Geological Survey Borehole, Warlingham, Surrey, at 2684 ft 3 in. depth. Lower Kimmeridgian (Autissiodorensis Zone).

DIMENSIONS: Figured specimen: overall length  $65\mu$ , breadth  $50\mu$ , apical horn length  $7.5\mu$ .

REMARKS: The long epitract, densely granular shell wall, elongate apical plate 1' and large postcingular plates 4'' and 5'' distinguish this form from all described species. It almost certainly represents an undescribed species of *Gonyaulacysta*, but before this can be decided, more specimens must be awaited.

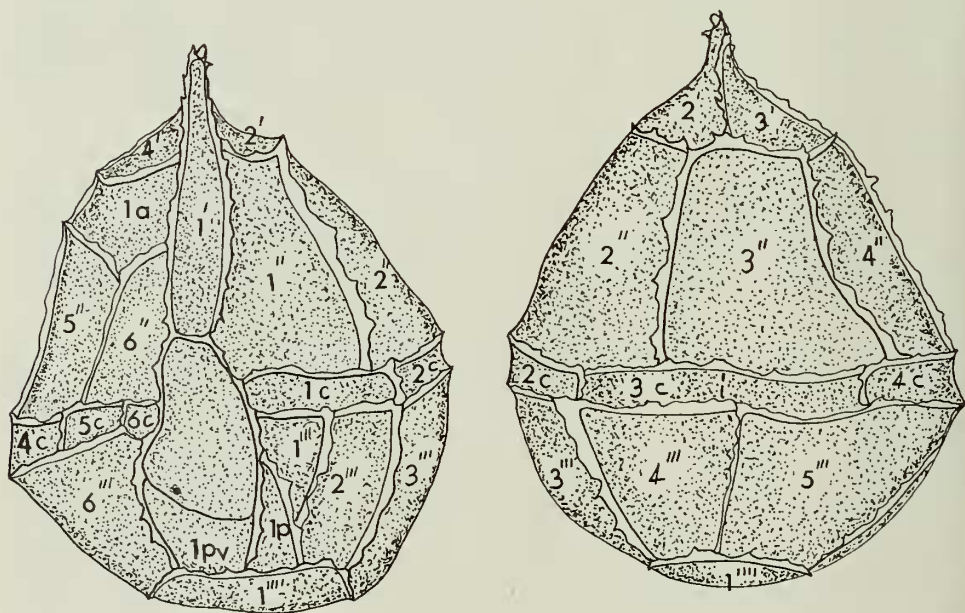


FIG. 13. *Gonyaulacysta* sp. E. Tabulation: left, in ventral view; right in dorsal view. Specimen I.G.S. slide PK 113.  $\times$  c.669.



*Gonyaulacysta* sp. F.

Plate 6, figures 3, 6; text-figure 14

DESCRIPTION: The cyst is elongate, with a long and tapering apical horn. The cyst wall is composed of two layers; a fairly thin endophragm and a thicker periphragm. The endophragm bulges into the lower half of the apical horn; the anterior portion of the horn is formed by the periphragm only, so that there is a cavity between the wall layers at the anterior end of the horn. Tabulation: 4', 1a, 6'', 6c, 6''', 1p, 1pv and 1'''. The four apical plates together make up the apical horn. Plate 1' is elongate, extending down two-thirds of the epitract. The anterior intercalary plate (1a) is quite large: because of this, precingular plate 6'' is reduced. The other precingular plates are relatively large. The postcingular plates 1''' and 6''' are small, the others are moderately large. The posterior intercalary plate (1p) is elongate: the boundary between the sulcus and the posterior ventral plate (1pv) was not confirmed. A single narrow plate occupies the antapex.

The cingulum is strongly helicoid, laevorotatory, dividing the cyst unequally, the epitract being longer than the hypotract. The sulcus is broad and largely confined to the hypotract.

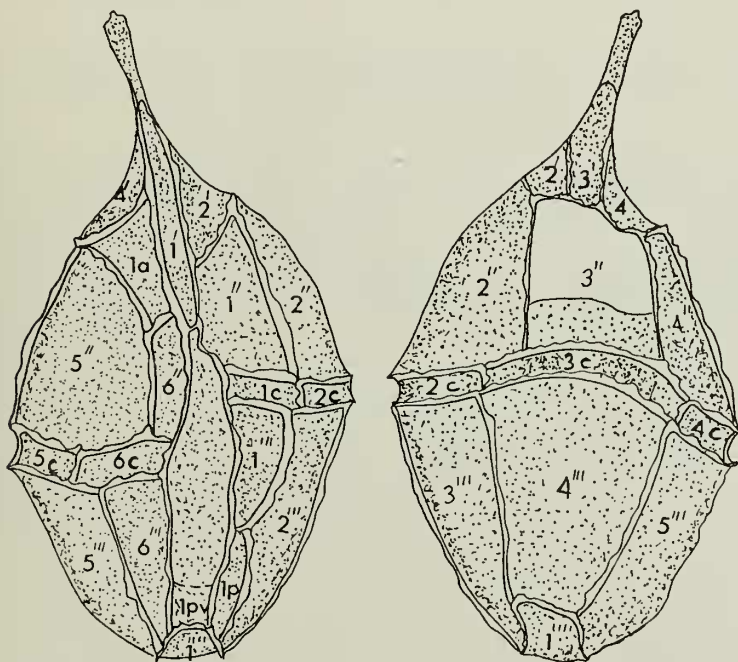


FIG. 14. *Gonyaulacysta* sp. F. Tabulation and archaeopyle formation (the operculum has partially slipped inside the cyst). Left, in ventral view; right, in dorsal view. Specimen BM(NH) slide V.56348 (1).  $\times$  c.983.

The plate boundaries are marked by crests in the form of very low, thick membranes. The surface of the shell is densely granular. A precingular archaeopyle forms by loss of plate 3''; on the figured specimen, the operculum is partially slipped inside.

FIGURED SPECIMEN: BM(NH) slide V.56348(1). Sample ED 240, from 30 ft above Freshwater Steps Stone Band, Egmont Bight, Dorset. Upper Kimmeridgian (Pectinatus Zone).

DIMENSIONS: Figured specimen: overall length  $92\mu$ , breadth  $52\mu$ , apical horn length  $26\mu$ .

REMARKS: The description of this species was based on a single specimen observed in the assemblages examined. In its overall morphology it is typically a species of *Gonyaulacysta*, but it is markedly different from all previously described species. It may be compared with *G. perforans*, since both have a similarly elongate theca, with long apical horn, and a comparable tabulation, but the crests on the sutures are completely different: *G. perforans* has well developed, porate membraneous crests, whereas this form has low, thick membraneous crests. *G. perforans* apparently has a single-layered wall, but in this species the shell wall is distinctly two layered. This specimen certainly represents a new species of *Gonyaulacysta* but, since the only specimen observed is not well preserved, no new name is given.

### *Gonyaulacysta* sp. G

Plate 6, figures 7-8; text-figure 15

DESCRIPTION: The cyst is broadly ovoidal, with a strong apical horn. Tabulation: 4', 6'', 6c, 6''', 1p, ?1pv and 1'''''. The apical plates 1' and 4' are broad and long, plates 2' and 3' are rounded, smaller. The precingular plates are moderately large, except for plates 1'' and 6'' which are somewhat smaller than the others. Plate 3'' is typically lost in archaeopyle formation. The postcingular plates 1''', 5''' and 6''' are small; in contrast, plates 3''' and 4''' are very large and occupy almost the whole dorsal side of the hypotract. The single antapical plate, 1''''', is quite large and convex; plate 1p is small. On the posterior portion of the sulcus some small plates were suggested, but their presence could not be confirmed: they may constitute a subdivided posterior ventral plate 1pv.

The cingulum is narrow, helicoid, laevorotatory, comprised of six cingular plates. It divides the cyst unequally into two parts, the epitract being smaller than the hypotract. The sulcus is short, mainly confined to the hypotract and broadening posteriorly.

The plate boundaries are marked by high, delicate crests, which have smooth edges and are irregularly perforate. The surface of the shell is densely granular. The dense granulation and high crests render the tabulation difficult to determine.

FIGURED SPECIMEN: BM(NH) slide V.56349(1). Sample HC 243, from c. 100 ft below the Rotunda Nodules, in the base of Hounstout Cliff, Dorset. Upper Kimmeridgian (Pectinatus Zone).

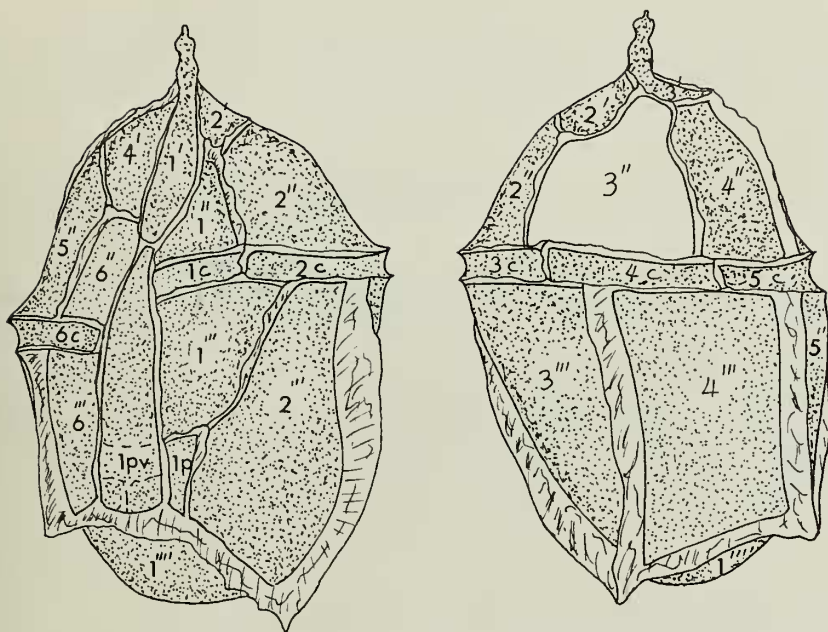


FIG. 15. *Gonyaulacysta* sp. G. Tabulation and archaeopyle formation (plate 3'' is missing). Left, in ventral view; right, in dorsal view. Specimen BM(NH) slide V.56349 (1).  $\times$  c.1024.

**DIMENSIONS:** Figured specimen: overall length  $75\mu$ , breadth  $45\mu$ , apical horn length  $10\mu$ , breadth of the cingulum  $5\mu$ .

**REMARKS:** This single specimen differs from the described species of *Gonyaulacysta* in its general shape and distinctive sutural crests. The tabulation and perforate crests are similar to those in *G. perforans*, but in the other morphological characters those species are dissimilar.

### *Gonyaulacysta* sp. H

Plate 13, figure 1, text-figure 16

**DESCRIPTION:** Cyst subpolygonal to ovoidal, with a strong apical horn of moderate length. The cyst wall is rather thick and composed of two layers, the periphragm alone forming the horn; the surface of the periphragm is densely and finely granular. Tabulation 4-?5', 1a, 6'', 6c, 5''', op, ?1pv, 1'''. The sutures are indicated by low ridges, from which arise small prominences, too blunt and short to be called spines. The number of apical plates is doubtful only because a small circular plate appears to cap the horn: four other plates can clearly be seen, plate 1' being unusually large and broad. Plate 6'' of the precingular series is reduced to accommodate an obliquely positioned anterior intercalary plate: plate 3'' is lost in archaeopyle formation.

The cingulum is narrow and pronouncedly laevorotatory, its two ends differing in antero-posterior position by three times its breadth. The sulcus is broad: it is widely separated from the apex by the enlarged plate 1', from the antapex (apparently) by a narrow posterior ventral plate, whose boundary was only doubtfully determined.

Only five postcingular plates appear to be present, the first being reduced: no posterior intercalary plate was determinable. The single antapical plate is relatively small.

FIGURED SPECIMEN: BM(NH) slide V.56339(1). Sample CH 231, Kimmeridge Clay (Wheatleyensis Zone) 22 ft below the Blackstone, Clavells Hard, Dorset.

DIMENSIONS: Figured specimen; overall length  $120\mu$ , length of apical horn  $30\mu$ , breadth  $72.5\mu$ , crests c.  $1.5\mu$  high.

REMARKS: This single specimen certainly represents an undescribed species of *Gonyaulacysta*, characterized by its shape and tabulation. In general proportions, it is akin to a number of other Upper Jurassic and Lower Cretaceous species, all of which, however, have more elaborate crests and a more complex tabulation.

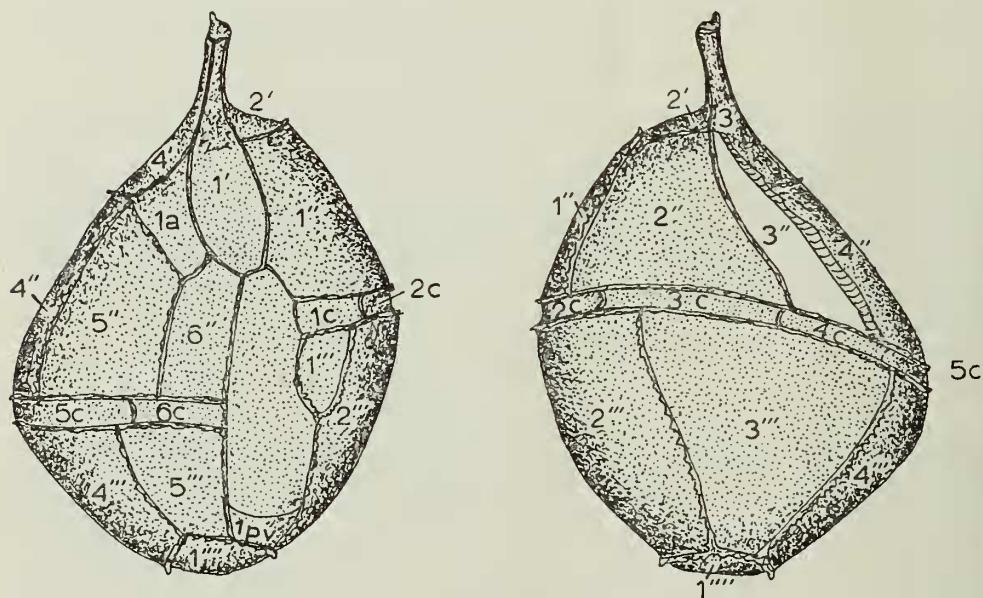


FIG. 16. *Gonyaulacysta* sp. H. Tabulation and archaeopyle formation (plate 3'' is missing). Left, in oblique ventral view; right, in oblique dorsal view. Specimen BM(NH) slide V.56339 (1).  $\times$  c.640.



Genus *LEPTODINIUM* Klement, 1960b emend. Sarjeant, 1969

*Leptodinium aceras* (Eisenack) Sarjeant, 1969, emend.

Plate 5, figures 1-3, text-figure 17

- 1958 *Gonyaulax aceras* Eisenack, 391, pl. 2, figs 1-2.  
 1962 *G. aceras* Eisenack; G. & M. Deflandre, fiche 1752.  
 1964 *G. aceras* Eisenack; Downie and Sarjeant, 113.  
 1964 *G. aceras* Eisenack; Eisenack, 311.  
 1966 ?*Gonyaulacysta aceras* (Eisenack); Sarjeant, *nomen nudum*, 131.  
 1967b *G. aceras* (Eisenack); Sarjeant, *nomen nudum*, table 1.  
 1967b *Gonyaulax aceras* Eisenack; Vozzhennikova, table II.  
 1969 *Leptodinium aceras* (Eisenack); Sarjeant, 12.

EMENDED DIAGNOSIS: Cyst broadly ovoidal to subspherical, without appendages, with tabulation 4', 1a, 6'', 6c, 6''', 1p, 1pv and 1'''''. Cingulum helicoid, laevorotatory; sulcus narrow, extending on both epitract and hypotract. Sutures in the form of low membraneous crests. Surface coarsely granular. Archaeopyle rarely developed, formed by loss of plate 3''.

HOLOTYPE: Tübingen, Geol.-Paläont. Institut, Pr. 1125, Ob. Apt. Nr. 9. Aptian, North Germany.

FIGURED SPECIMENS: I.G.S. slide PK.108. Sample WB 7, from H.M. Geological Survey Borehole, Warlingham, Surrey, at 2834 ft 7 in. depth. Lower Kimmeridgian (Eudoxus Zone).

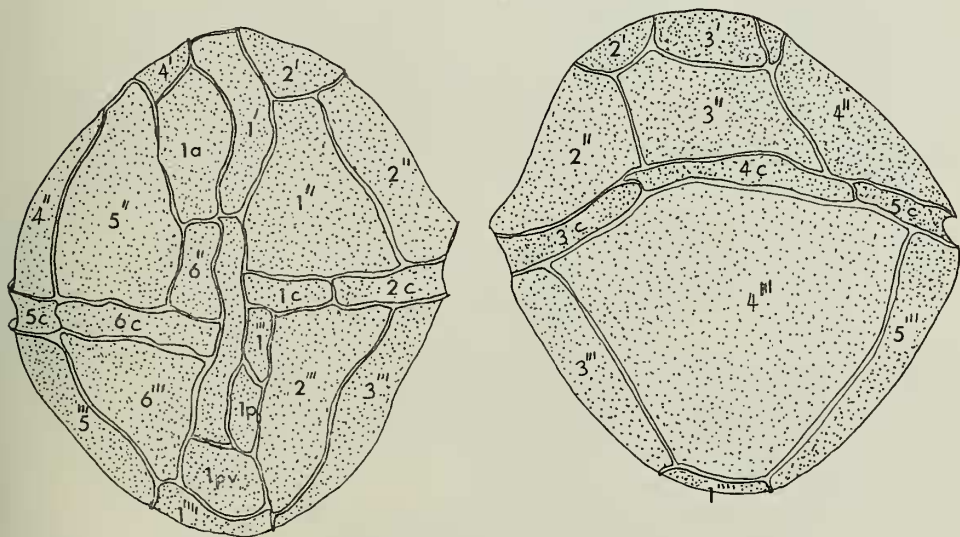


FIG. 17. *Leptodinium aceras* (Eisenack). Tabulation: left, in ventral view; right, in dorsal view. I.G.S. slide PK 108.  $\times$  c.1041.



I.G.S. slide PK.112. Sample WB 13, from the Warlingham Borehole, at 2684 ft 3 in. depth. Lower Kimmeridgian (Autissiodorensis Zone).

**DIMENSIONS:** Holotype: overall length  $85\mu$ , breadth  $71\mu$ . Range of the observed specimens, which are 16 in number; overall length 60–95 $\mu$ , breadth 52–90 $\mu$ .

**DESCRIPTION:** The moderately thick-walled cyst is divided into two unequal parts by the relatively narrow cingulum. The epitract is slightly longer than the hypotract: both are dome-shaped.

Four apical plates, of variable shape and size, make up the apex: plate 1' is elongate and sigmoidal, almost as long as the sulcus, and extending down two-thirds of the epitract. Plates 2' and 3' are quite large; plate 4' is reduced because of the larger anterior intercalary plate (1a), which is also the reason for the reduction of precingular plate 6''. The other precingular plates are relatively large. The cingular plates are narrow and long, plate 1c being smallest. Six postcingular plates are present, with plate 1''' reduced and triangular. Plate 4''' is the largest plate of the cyst. The intercalary plate (1p) is placed below the plate 1''', its outbulge causing the sulcus to become narrower. A quite large plate, 1pv, separates the single antapical plate 1'''' from the sulcus and plate 1p.

**OBSERVED RANGE:** Kimmeridgian (Autissiodorensis to Pectinatus).

**TOTAL KNOWN RANGE:** Kimmeridgian (Autissiodorensis to Pectinatus) and Aptian.

**REMARKS:** The diagnosis is emended to include reference to the tabulation and the mode of archaeopyle formation. (In his original diagnosis, Eisenack was unable to give the tabulation pattern.) Sixteen specimens were observed in the Kimmeridgian assemblages from England: although they were not perfectly preserved, it was possible to determine the tabulation, one of them (the figured specimen) showing it particularly well. A precingular archaeopyle was observed in only two of the specimens; an archaeopyle of this type is figured by Eisenack, who recorded this species from the Aptian of Germany and placed it in *Gonyaulax*. Since it has no apical horn it was transferred to the genus *Leptodinium* by Sarjeant (1969).

### *Leptodinium amabilis* (Deflandre) Sarjeant, 1969

Plate 10, figures 5–6, text-figure 18

- 1939b *Gonyaulax amabilis* Deflandre, 143, pl. 6, fig. 8.
- 1941b *G. amabilis* Deflandre; Deflandre, 11, pl. 3, figs 8–9, text-figs 1–2.
- 1962 *G. amabilis* Deflandre; G. & M. Deflandre, fiche 1755.
- 1964 *G. amabilis* Deflandre; Downie and Sarjeant, 113.
- 1964 *G. amabilis* Deflandre; Eisenack, 315–316.
- 1964 *G. amabilis* Deflandre; Sarjeant, table 2.
- 1966 *Gonyaulacysta amabilis* (Deflandre); Sarjeant, *nomen nudum*, 130.
- 1967b *G. amabilis* (Deflandre); Sarjeant, *nomen nudum*, table 1.
- 1967b *Gonyaulax amabilis* Deflandre; Vozzhennikova, 91, table 11.
- 1969 *Leptodinium amabilis* (Deflandre); Sarjeant, 12.
- 1970 *L. amabilis* (Deflandre); Gitmez, 269–70, pl. 12, figs 1–2.

DESCRIPTION: The cyst is broadly ovoidal, with the tabulation 4', 6'', 6c, 6''', 1p, 1pv, 1'''''. The strongly spiral cingulum divides the cyst more or less equally. The sulcus is long and extends onto both epitract and hypotract, being narrow on the epitract. Moderately high crests arise from the sutures, distally feebly denticulate or smooth. The surface of the shell is smooth or finely granular. A precingular archaeopyle is sometimes developed, by loss of plate 3''.

FIGURED SPECIMEN: BM(NH) slide V.56350(1). Sample OF 485, from the road side, Montard d'Oignon, France. Lower Kimmeridgian (Mutabilis Zone).

DIMENSIONS: Figured specimen: overall length  $38\mu$ , breadth  $34\mu$ . Range of the observed specimens (8 in number): length  $38$ – $50\mu$ , breadth  $34$ – $45\mu$ , sutures length  $3$ – $4\mu$ . Deflandre gave the dimensions of the holotype as length  $38\mu$ , breadth  $32\mu$ . The observed specimens are larger than the holotype.

REMARKS: *L. amabilis* has been previously recorded only from the Kimmeridgian of France. It was infrequent in the samples from England and France, five specimens from the Lower Kimmeridgian (Baylei to Mutabilis Zones) and three specimens from the Upper Kimmeridgian (Pectinatus) being observed. It is recorded from English assemblages for the first time: the mode of archaeopyle formation for this species is also recorded for the first time. In general structure and tabulation, the observed specimens correspond closely to the holotype.

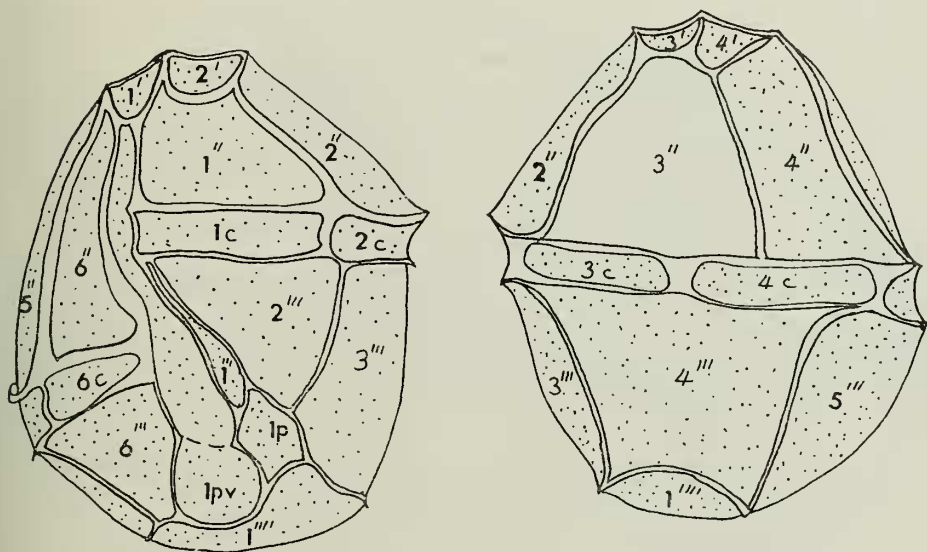


FIG. 18. *Leptodinium amabilis* (Deflandre). Tabulation and archaeopyle formation (plate 3'' is missing): left, in ventral view; right, in dorsal view. Specimen BM(NH) slide V.56350 (1).  $\times$  c.1690.

*Leptodinium* cf. *crassinervum* (Deflandre) Sarjeant, 1969

Plate 3, figure 8, plate 5, figures 4-6; text-figure 19

DESCRIPTION: The shell is broadly ovoidal to polygonal in shape. The cyst wall is thick (c.  $2.5\mu$ ) and densely granular. The crests are membraneous in character and arise from slight thickenings of the periphragm; although they are low, they are quite obvious. They give rise to occasional short spines, up to c.  $4-4.5\mu$  in height. Tabulation: 4', 1a, 6'', 6c, 6''', 1p, 1pv, 1'''' and 2s. Plate 1' is elongate, extending down almost two-thirds of the epitract. Plates 2', 3' and 4' are more or less equal in size. The precingular plates are relatively large, except plate 6'' which is reduced because of the large anterior intercalary plate (1a). The six postcingular plates are of variable shape and size: plate 2''' is reduced to accommodate the intercalary plate (1p) which is rather large. Plate 1''' is quite small; the other postcingular plates are relatively large, plate 4''' being the largest of all the plates. A crescent-shaped posterior ventral plate, 1pv, separates the sulcal plates from the single antapical plate.

The cingulum is moderately narrow, formed by six plates (plate 6c is very small); it is slightly spiral, laevorotatory and divides the theca unequally: the epitract is twice as large as the hypotract. The sulcus is short and broad; its posterior portion is formed by two sulcal plates, one small, the second quite large.

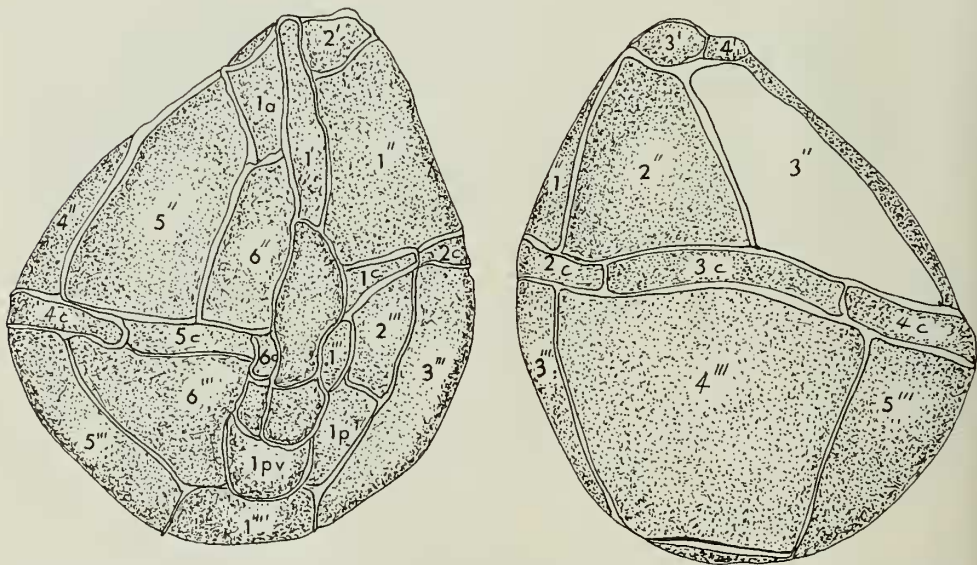


FIG. 19. *Leptodinium* cf. *crassinervum* (Deflandre). Tabulation and archaeopyle formation: left, in ventral view; right, in dorsal view. Specimen BM(NH) slide V.56346 (1).  $\times$  c.960.

On the dorsal side of the shell, a large precingular archaeopyle is formed by loss of plate 3''.

FIGURED SPECIMENS: BM(NH) slide V.56346(1), (3) and V.56351(1), Sample LO 353 from the Littleworth Quarry, Oxfordshire. Upper Kimmeridgian (Pallasioides Zone).

DIMENSIONS: Range of the observed specimens: overall length 68–80 $\mu$ , breadth 50–68 $\mu$ . Measured specimens 4 in number.

Deflandre gave the following dimensions for *L. crassinervum*: length 82 $\mu$ , breadth 69 $\mu$ . The English Kimmeridgian specimens found which are similar to Deflandre's specimen, are slightly smaller.

REMARKS: *L. crassinervum* has been recorded only from the Kimmeridgian of France (by Deflandre); the species was based on a single specimen and, because of its poor preservation, Deflandre was unable to determine the tabulation. Later Sarjeant re-studied the holotype and, on the basis of its similarity to other Jurassic species, re-attributed it to *Gonyaulacysta*. Recently, it was transferred to *Leptodinium*, on the basis of its lack of an apical horn.

Four specimens observed, all from the Pallasioides Zone of England (sample LO 353), exhibit a strong resemblance, in their long epitract and thick shell wall, to *L. crassinervum*, but could not be attributed to that species with confidence, in absence of knowledge of the tabulation of the holotype.

### *Leptodinium* sp.

Plate 3, figure 9; text-figure 20

DESCRIPTION: Cyst spherical to subspherical, an appearance of polygonality being imparted by the crests. Tabulation: 4', 1a, 6'', 6c, 6''', 1p, 1''''; plate boundaries bearing relatively high, delicate, distally denticulate crests.

The first apical plate, 1', is long and narrow, occupying the anterior extension of the sulcus. Plates 2' and 3' are comparable in shape and size, but plate 4' is markedly larger. Between the plates 1' and 4', a small, elongate intercalary plate (1a) is accommodated. The precingular plates are generally large, except plate 6'', which is narrow. The postcingular plates are also all quite large. Plate 6''' is slightly reduced. Because of the bad orientation of the specimen, the exact shape and size of plates 1''' and 2''' is not very clear, but plates 3''' and 4''' appear the largest of all the plates. The single large antapical plate (1''') is pronouncedly convex.

The cingulum is strongly helicoid, laevorotatory, occupied by six relatively large cingular plates. It divides the cyst unequally: the sulcus is sigmoidal in shape and extends between the apex and antapex, narrowing to the two ends.

The surface is smooth and the wall is transparent. A precingular archaeopyle formed by loss of plate 3'' was observed in some of the specimens.

FIGURED SPECIMEN: BM(NH) slide V.56352, sample HC 246, from 140 ft below the Massive Bed, Hounstout Cliff, Dorset. Upper Kimmeridgian (Rotunda Zone).



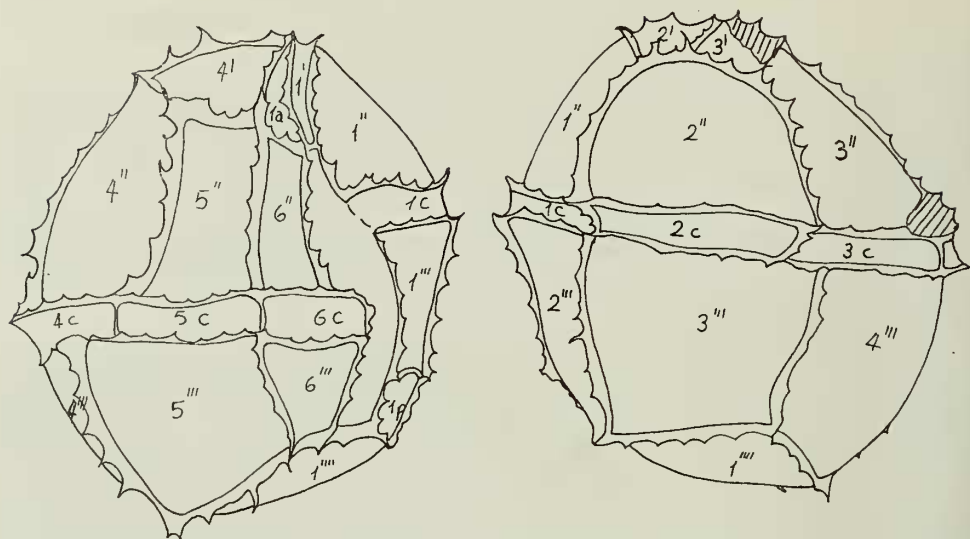


FIG. 20. *Leptodinium* sp. Tabulation and archaeopyle formation (plate 3'' is missing): left, in oblique ventral view; right, in oblique dorsal view. BM(NH) slide V.56352.  $\times$  c.1620.

DIMENSIONS: Figured specimen: overall length  $40\mu$ , breadth  $40\mu$ .

RANGE: Length  $40$ – $60\mu$ , breadth  $30$ – $52\mu$ . Measured specimens 11 in number.

OBSERVED RANGE: Kimmeridgian (Wheatleyensis to Rotunda).

REMARKS: Twelve specimens were observed in the Middle-Upper Kimmeridgian assemblages of England, which are comparable in their morphological features to *Leptodinium*, but differ from the other species of this genus. They possibly represent a new species. Unfortunately, all the specimens observed are somewhat crushed, folded and in a bad orientation; the figured specimen was the best. The small size and the transparent shell wall of the specimens increase the difficulty of determining the tabulation. Accordingly, no new specific name for these forms can yet be proposed.

The most closely comparable species is *L. amabilis*, which is similarly small. However, these Kimmeridgian forms are clearly distinguished by the character of their crests, the presence of an anterior intercalary plate, the absence of the posterior ventral plate and the details of the rest of the tabulation.

Genus *OCCISUCYSTA* Gitmez, 1969

*Occisucysta evitti* (Dodekova) Gitmez, 1970

1969 *Gonyaulacysta evitti* Dodekova, 14–15, pl. 1, figs 1–8, table 1.

1970 *Occisucysta evitti* (Dodekova); Gitmez, 269.

DESCRIPTION: Cyst spherical, with the tabulation 4', ?1a, 6'', 6–7c, 7''', 1p, 1pv, 1'''. No true apical horn appears to be present, the apical prominence being



formed by the confluence of crests. The cingulum is strongly helicoid, laevorotatory, dividing the cyst unequally: the epitract is slightly longer than the hypotract. The sulcus is short. The sutures bear delicate, perforate, membraneous crests, with denticulate edges. Around the apex, the crests are apparently higher than elsewhere. The surface is granular and tuberculate, also possessing lines of small spines which form "double sutures", parallel to the true sutures. A precingular archaeopyle is formed by loss of plates 2'' and 3''.

HOLOTYPE: Dodekova's collection, Jmp/DO-r6. Tithonian, Bulgaria.

DIMENSIONS: Holotype: overall length  $82\mu$ , breadth  $82\mu$ , crests  $4\mu$ , high on the sutures, apical crests  $8\mu$  high.

REMARKS: The description and dimensions mentioned here are as given by Dodekova. This species is characterized by a two-plate precingular archaeopyle. Although Dodekova did not mention the anterior intercalary plate (1a), the photographs of the holotype of *G. evitti* show that the plate above 6'' (which was indicated as plate 4') is, in fact, plate 1a, a boundary being present at its anterior end, separating off a small plate 4'. The position of the plates 7''' and 1pv is exactly the same as in *O. balios*. In tabulation and the character of archaeopyle, therefore, this species corresponds to the genus *Occisucysta* and is accordingly reallocated to it, despite the lack of a true apical horn. Erection of a second genus, to accommodate hornless forms, may prove desirable in the future.

***Occisucysta monoheuriskos* sp. nov.**

Plate 7, figures 10-11, text-figure 21

DERIVATION OF THE NAME: Greek, *monos*, one, single, *heurisko*, find, discover; referring to the discovery of a single specimen.

DIAGNOSIS: A species of *Occisucysta* with a globular cyst. Tabulation: 4', 6'', 7c, 7''', 1p, 1pv, 1''', 2s. The epitract and hypotract are almost equal in size, separated by the only slightly spiral, laevorotatory cingulum. The sulcus is broad and short, stretching from about mid-point on the epitract to about mid-point on the hypotract. The surface is finely granular and sparsely tuberculate. Sutures are in the form of spine rows; the spines are distally closed, oblate or bifid, generally simple, but the spines near to the apical horn are connected distally and thus appear more complicated. Short spines surround the distal end of the apical horn like a corona. A two-plate precingular archaeopyle is typically present, forming by loss of plates 2'' and 3''.

HOLOTYPE: BM(NH) slide V.56353(1). Sample CS 421, from the Sand Stone dyke, first lower Meleagrinella Band of Eathie Haven, South Cromarty, Scotland, Lower Kimmeridgian (Cymodoce Zone).

DIMENSIONS: Holotype: overall length  $70\mu$ , breadth  $65\mu$ , horn length  $10\mu$ ; length of the sutural spines  $5\mu$ , length of the spines surrounding the apical horn  $3\mu$ .

DESCRIPTION: The cyst wall is relatively thick, c.  $1.5\mu$ . The cylindrical horn rises from the top of the dome-shaped epitract and is formed by two of the four apical

plates, 1' and 2'. Plate 1' is elongate and broad, corresponding in position to the anterior prolongation of the sulcus. The other three apical plates are relatively large and of more or less equal size. The six precingular plates, together with the apical plates, make up the epitract; no intercalary plates are present. Except for plate 6'', which is narrow and elongate, the precingular plates are quite large; plates 2'' and 3'' are lost in archaeopyle formation. The cingulum is occupied by 7 plates of variable size, the first and last (1c and 7c) being small. The ends of the cingulum are widely separated by a very broad sulcus, which widens further in its posterior portion. Two small plates are developed in the mid-portion of the sulcus.

The hypotract is hemi-spherical. The first postcingular plate (1''') is small, quadrate and placed in the flank of the sulcus. Plate 2''' is roughly triangular, and, because of the presence of the intercalary plate (1p), is reduced in size. Plates 3''', 4''' and 5''' are very large. Plate 6''' is narrow and elongate; plate 7''' is small. The single, convex antapical plate (1''') is quite large. Two intercalary plates, 1p and 1pv, together form a crescent shape; 1pv separates the sulcus from the antapex.

REMARKS: *O. monoheuriskos* has been found in only one sample (CS 421) and only one well preserved specimen has so far been observed. Its general shape, tabulation and the sutural features, combined with the two-plate precingular archaeopyle, agree with the diagnosis of the genus *Occisucysta*. Since all the morphologic features are discernible on the one well-preserved specimen, it is proposed without hesitation as a new species of *Occisucysta*.

*O. monoheuriskos* is distinguished from the two other described species of the genus by its apical horn of different form and aspect, its lack of an anterior inter-

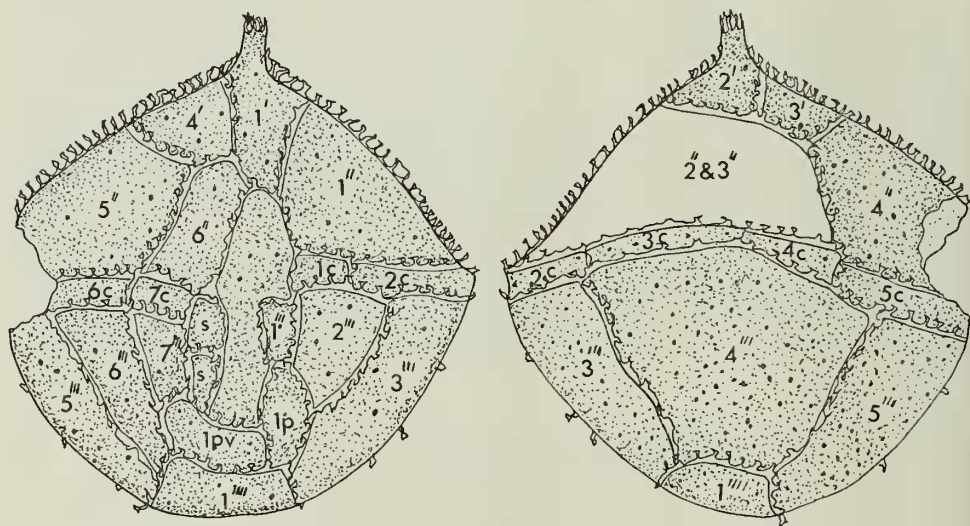


FIG. 21. *Occisucysta monoheuriskos* sp. nov. Tabulation and archaeopyle formation (plates 2'' and 3'' are missing): left, in ventral view; right, in dorsal view. Holotype: BM(NH) slide V.56353 (1).  $\times$  c.1041.

calary plate, and a number of details of the tabulation. In its possession of a cylindrical apical horn distally surrounded by spines and its spinous sutures, it shows some similarity to *Occisucysta* sp. of Gitmez (1969), but since bad preservation precluded any detailed knowledge of *Occisucysta* sp., an extended comparison is not possible.

Cyst-Family **MICRODINIACEAE** Eisenack, 1964, emend. Sarjeant and Downie, 1966

Genus **DICTYOPYXIS** Cookson and Eisenack, 1960b

***Dictyopyxis areolata*** Cookson and Eisenack, 1960b

Plate 7, figure 9

- 1955 *Membranilarnax ovulum* Valensi, 590, pl. 2, fig. 4, pl. 5, fig. 6.  
 1960b *Dictyopyxis areolata* Cookson and Eisenack, 255-6, pl. 39, figs 12-14.  
 1961 *Dictyopyxidia areolata* (Cookson and Eisenack); Eisenack, *nomen nudum*, 316.  
 1962b *Dictyopyxis areolata* Cookson and Eisenack; Sarjeant, 494, pl. 70, fig. 19; text-fig. 13, tables 2-3.  
 1964 *Dictyopyxidia areolata* (Cookson and Eisenack); Downie and Sarjeant, *nomen nudum* 110.  
 1964 *Dictyopyxis areolata* Cookson and Eisenack; Sarjeant, table 3.  
 1966b *Ellipsoidictyum areolata* (Cookson and Eisenack); G. & M. Deflandre, fiches 3318-9.  
 1967b *Dictyopyxidia areolata* (Cookson and Eisenack); Sarjeant, *nomen nudum* table 2.  
 1968 *Dictyopyxis areolata* Cookson and Eisenack; Sarjeant, 229-30, pl. 1, fig. 1; text-fig. 5.  
 1970 *Dictyopyxis* sp. Gitmez, 275-6, pl. 1, fig. 1, table 4.

**DESCRIPTION:** This form is characterized by its highly reticulate surface. Each small field is demarcated by high sutures. The cyst is ovoidal to subspherical in shape. The arrangement of reticulae as a pattern of tabulation suggested by Sarjeant (1968) was not determined; however, some small fields on the equatorial plane together form a median line, which may well be equivalent to the cingulum. The apex is lost in archaeopyle formation.

**FIGURED SPECIMEN:** BM(NH) slide V.53956(1). Sample OM 420, from 20 ft above the Ringstead Coral Bed, west of Osmington Mills, Dorset. Lower Kimmeridgian (Baylei Zone).

**DIMENSIONS:** Figured specimen: overall length (apex lacking) 55 $\mu$ , breadth 50 $\mu$ . Range of the English specimens (3 specimens were measured): overall length 50-55 $\mu$ , length without apex 30 $\mu$ , breadth 40-50 $\mu$ . Scottish specimens: length (apex lacking) 45-60 $\mu$ , breadth 40-55 $\mu$  (3 specimens measured). French specimens: overall length 50-60 $\mu$ , length without apex 35-50 $\mu$ , breadth 35-52 $\mu$  (6 specimens measured).

Cookson and Eisenack gave the range for the Australian specimens as 86-124 $\mu$  length and 54-66 $\mu$  breadth, which makes them larger than the European Kimmeridgian specimens.

**OBSERVED RANGE:** Lower Kimmeridgian (Baylei to Mutabilis).

**TOTAL KNOWN RANGE:** Upper Callovian (Lamberti) to Lower Kimmeridgian (Mutabilis).

REMARKS: *D. areolata* was described originally from the Oxfordian to Lower Kimmeridgian of Australia; subsequently, Sarjeant recorded it from the Oxfordian of England (1962) and the Callovian of France (1968). The specimens illustrated by Valensi as *Membranilarnax ovulum*, from Magdalenian flints of presumed Upper Jurassic age, appear attributable to this species.

Three specimens from Scotland, eight specimens from France and four specimens from England were observed; they occur only in the Lower Kimmeridgian assemblages. These specimens agree in their morphologic features with the holotype of *D. areolata*.

***Dictyopyxis* cf. *reticulata* (Valensi) Sarjeant, 1968**

Plate 7, figures 4–5; Plate 12, figures 1–2

DESCRIPTION: The shell is ovoidal with a reticulate surface; the reticulation is irregular. The crests surrounding the small areas are not so high as in *D. areolata*. Spines rise up from the crest nodes; they are solid, simple, oblate or bifid. There is no obvious tabulation, but more regularly formed reticulae make up a median band equivalent to a cingulum. A large apical archaeopyle, with polygonal outline, is developed.

FIGURED SPECIMENS: BM(NH) slide V.56354(1). Sample OF 485, from the road side, Montard d'Oignon, France. Lower Kimmeridgian (Mutabilis Zone).

BM(NH) slide V.56355(1). Sample 486, from the top of the Oignon Beds, west of Lac du Chavoley, France. Lower Kimmeridgian (Mutabilis Zone).

DIMENSIONS: Range of the French specimens (7 specimens measured) overall length 50–61 $\mu$ , length without apex 30–55 $\mu$ , breadth 23–65 $\mu$ , spine length 6–8 $\mu$ . Scottish specimen: length (apex lacking) 35 $\mu$ , breadth 48 $\mu$ . Valensi gave the dimensions for this species as 45 $\mu$  length (apex lacking) and 52 $\mu$  breadth, spine length, 3 $\mu$ . The Kimmeridgian specimens are similar in size, but their spines are longer than those of the holotype.

REMARKS: *D. reticulata* was recorded from the Bajocian of Calvados and Bathonian of Vienne, as a species of *Palaeoperidinium*, by Valensi. It was transferred to the genus *Dictyopyxis* by Sarjeant (1968). Single specimens from the Cymodoce Zone of Scotland and France and eight specimens from the Mutabilis Zone of France were recorded, which are closely similar to the specimen figured by Valensi, except for a greater length of the spines arising from the crest nodes. In view of this minor difference in morphology and the stratigraphical hiatus, these nine specimens were compared with, but not placed in, *D. reticulata*.

Genus ***MEIOUROGONYAULAX*** Sarjeant, 1966a

***Meiourogonyaulax staffinensis*** Gitmez, 1970

Plate 9, fig. 4

1970 *Meiourogonyaulax staffinensis* Gitmez, 276–8, pl. 3, fig. 1, text-fig 20 a, b.

FIGURED SPECIMEN: BM(NH) slide V.56356, specimen ED 242, Kimmeridge Clay



(Pectinatus Zone) 60 ft above Freshwater Steps Stone Band, Egmont Bight, Dorset.

DIMENSIONS: Overall length (apex lacking)  $84\mu$ , overall breadth  $91.5\mu$ , length of cyst alone  $72\mu$ , breadth  $81.5\mu$ , height of crests  $5-9\mu$ .

RANGE OF DIMENSIONS: Overall length (apex lacking)  $45-98\mu$ , overall breadth  $42-91.5\mu$ .

OBSERVED RANGE: Kimmeridgian (Baylei to Pallasioides).

REMARKS: This species, hitherto recorded only from the Baylei Zone, ranges throughout the Kimmeridgian (though it has not been encountered in some zones). The size range here quoted is significantly greater than that originally quoted (overall length  $48-80\mu$ , overall breadth  $45-78\mu$ ): the specimen figured is one of the largest encountered.

*Meiourogonyaulax dicryptos* sp. nov.

Plate 7, figure 6; text-figure 22

DERIVATION OF THE NAME: Greek, *di-*, two, double; *krypto*, cover; referring to the two-layered shell wall.

DIAGNOSIS: Cyst subspherical to spherical, with the tabulation  $4'$ ,  $6''$ ,  $6c$ ,  $7'''$ ,  $1p$ ,  $1'''$ , poorly marked by low ridges. Cingulum more or less equatorial and circular. Sulcus deep, short, confined to the hypotract, broadening towards the antapex. Cyst wall thick and composed of two layers: thick endophragm and thin periphragm. The periphragm bulges out on the apex to form a blunt apical horn, a cavity being developed between the two layers. Surface of the cyst is densely granular. Apical archaeopyle always present: sometimes the operculum remains attached to the shell, ventrally.

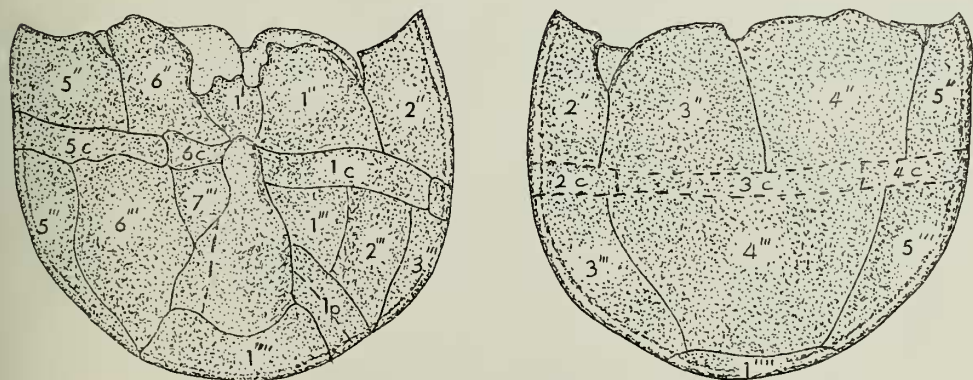


FIG. 22. *Meiourogonyaulax dicryptos* sp. nov. Tabulation and archaeopyle formation: left, in ventral view; right, in dorsal view. Holotype, specimen BM(NH) slide V.56357 (1).  $\times c.1063$ .



HOLOTYPE: BM(NH) slide V.56357(1). Sample BN 179, from the Marnes à Harpagodes, Benerville, Normandy. Lower Kimmeridgian (Cymodoce Zone).

DIMENSIONS: Holotype: length (apex lacking)  $40\mu$ , breadth  $52\mu$ .

RANGE: overall length  $70-90\mu$ , breadth  $52-88\mu$ , length (apex lacking)  $40-64\mu$ . Measured specimens 8 in number.

DESCRIPTION: The spherical to subspherical cyst is divided into two equal parts by the moderately narrow cingulum. Both epitract and hypotract are dome-shaped; the epitract bears a small, blunt, hollow apical horn. Four apical and six precingular plates make up the epitract: plate 1' is elongate, the other apical plates are broader. Plates 1'' and 6'' are somewhat reduced and plates 2'' and 5'' are the largest of the precingular plates. Seven postcingular plates are present on the hypotract. Plates 1''' and 2''' are reduced because of the presence of a large intercalary plate (1p). Plates 3''', 4''', 5''' and 6''' are relatively large; plate 7''' is reduced. The single antapical plate (1''') is quite large and convex. The cingulum is poorly indicated, formed by six plates of variable size. The sulcus is deep and, in its posterior portion, very wide. An apical archaeopyle forms by loss of the apical plates.

OBSERVED RANGE: Kimmeridgian (Cymodoce, Pectinatus and Rotunda Zones).

REMARKS: Eight specimens (one from France, seven from England) were recorded. These specimens differ from the other species of the genus in the character of their tabulation and possession of a hollow apical horn. In the presence of a seventh postcingular plate, this new species differs from the typical *Meiourogonyaualax* tabulation: however, it corresponds in all other respects.

*Meiourogonyaualax pila* sp. nov.

Plate 4, figure 5, plate 7, figure 3; text-figure 23

DERIVATION OF THE NAME: Latin, *pila*, ball; referring to the shape of the cyst.

DIAGNOSIS: Cyst almost circular in outline, without an apical horn and rounded at the antapex. Wall moderately thin, surface finely granular. Tabulation: 4', 6'', 6c, 6''', 1p, 1pv and 1'''''. Plate boundaries faintly indicated. The cingulum forms a feebly laevorotatory spiral. Apical archaeopyle typically present, with operculum attached ventrally.

HOLOTYPE: BM(NH) Slide V.56358; sample FD 236, from  $\frac{1}{4}$  mile west of Freshwater Steps, Dorset. Middle Kimmeridgian (on the boundary of the Pectinatus and Hudlestoni Zones).

PARATYPE: I.G.S. Slide PK.121, sample WB 19, from H.M. Geological Survey Borehole, Warlingham, Surrey, at 2535 ft 3in. depth. Middle Kimmeridgian (Wheatleyensis Zone).

DIMENSIONS: Holotype: overall length  $60\mu$ , breadth  $55\mu$ . Range of the observed specimens (19 in number): length  $55-75\mu$ , breadth  $55-70\mu$ .

DESCRIPTION: The spherical cyst is divided by the moderately wide and more or less equatorial cingulum into two parts, the epitract and the hypotract; these may

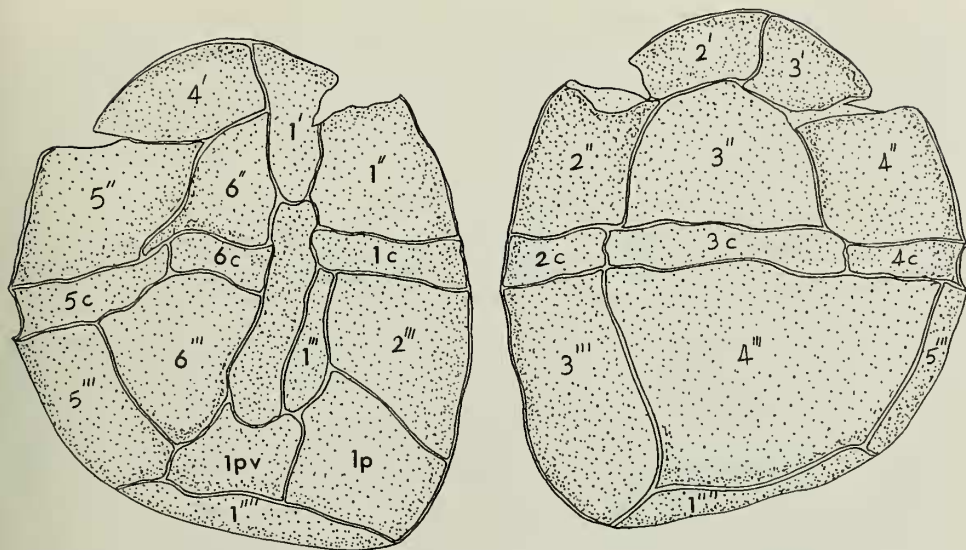


FIG. 23. *Meiourogonyaulax pila* sp. nov. The holotype, with attached operculum. Left, in ventral view; right, in dorsal view. BM(NH) slide V.56358.  $\times$  c.1018.

be equal in size or the hypotract may be slightly longer than the epitract. The sulcus is relatively short, mainly placed on the hypotract.

Plate 1' is elongate, the other three apical plates are more or less similar in shape and size. The precingular plates are generally almost equal in size, except that plate 6'' is smaller than the others. The postcingular plates are of variable size: plate 1''' is relatively small, plate 4''' is the largest of all the plates. A quite large intercalary plate (1p) is situated between the plates 2''' and 1'''; plate 2'' is correspondingly reduced. A large posterior ventral plate (1pv) separates the sulcus from the antapex. A single antapical plate, broad and slightly convex, occupies the antapex. Plate boundaries are marked by low ridges.

REMARKS: In general appearance, *M. pila* is similar to the members of the genus *Canningia*, for example *C. minor* and *C. ringnesii*; however, since the species of *Canningia* exhibit no tabulation, except for the weakly indicated cingulum, there is no possibility of confusion with *M. pila*. Because of the tabulation and apical archeopyle, the species is clearly attributable to *Meiourogonyaulax*. *M. pila* was recorded from the Middle and Upper Kimmeridgian (Scitulus to Rotunda Zones) from England only: it was not observed in Lower Kimmeridgian assemblages.

### *Meiourogonyaulax* sp.

Plate 4, figure 4, plate 7, figure 12

DESCRIPTION: Cyst broadly ovoidal, almost spherical in shape, without apical horn and with rounded antapex. There is often no indication of tabulation, but in

some of the specimens two apical and three precingular plates were recognised with difficulty on the dorsal side. The cingulum is frequently weakly indicated. The cyst wall is thick and is densely granular. An apical archaeopyle is typically present, formed by the rupture of the apex along a more or less straight line with small V-shaped notches along the edge, corresponding to the positions of sutures. Generally, the operculum remains attached ventrally.

FIGURED SPECIMENS: BM(NH) slide V.56359(1). Sample LO 352 from the Littleworth quarry, Oxfordshire. Upper Kimmeridgian (Pallasioides Zone). I.G.S. slide PK.100, sample WB 1, from H.M. Geological Survey Borehole, Warlingham, Surrey, at 7984 ft 7 in. depth. Lower Kimmeridgian (Mutabilis Zone).

DIMENSIONS: Figured specimen from Warlingham Borehole: overall length  $75\mu$ , breadth  $68\mu$ . Figured specimen from Littleworth: overall length  $63\mu$ , breadth  $60\mu$ . Range: overall length  $48-95\mu$ , breadth  $46-85\mu$ . Measured specimens 15 in number.

REMARKS: A group of specimens (22 in number) observed in the Kimmeridgian of England are, in their general appearance, with granular surface and attached operculum, similar to *Canningia ringnesii* (recorded from the Upper Cretaceous of the Arctic by Manum and Cookson, 1964). However, they differ in that they have a relatively thick cyst wall and tabulation (albeit poorly indicated). Because of the mode of archaeopyle formation and the slight indication of a tabulation, these specimens are allocated to the genus *Meiourogonyaulax*. It is possible that they may be intermediate forms between the two genera, in which the tabulation is becoming progressively less apparent.

#### Genus *EGMONTODINIUM* gen. nov.

DERIVATION OF NAME: Named after the type locality—Egmont Bight, Dorset.

DIAGNOSIS: Proximate cyst, spherical to ovoidal. Tabulation typically 4', 5 or 6 ac., 6'', 6c, 6''', op, 2pv, 6pc, 1''''': additional, very small platelets may be developed at crest nodes and the posterior tabulation is subject to some variation. No apical or other horns are developed. Crests or spinelets may arise from the sutures and spines may also be present, singly or in rows, on some plates. Archaeopyle apical, formed by schism along the anterior circle; the operculum frequently remains attached.

TYPE SPECIES: *Egmontodinium polyplacophorum* sp. nov. Kimmeridge Clay (Kimmeridgian: Pectinatus Zone), Egmont Bight, Dorset.

REMARKS: This genus is distinguished from all others yet described in its tabulation. The plates surrounding the apex might be termed anterior intercalaries: the authors, however, feel that this would be inappropriate, since they are not merely interposed between existing reflected plate series but constitute an additional series. The new name "anterior circle plate" is thus coined for them. The plates surrounding the antapex are similarly designated "posterior circle plates", following the precedent of another Jurassic genus, *Pluriarvalium*.

The most comparable genus is *Ellipsoidictyum* Klement 1960, whose complex tabulation was described in detail by Gocht (1970, pp. 150-2): however, the tabula-

tion of the epitract of this genus is markedly dissimilar and a close affinity cannot be considered probable.

The familial allocation of this genus is based on its proximate character and apical archaeopyle: the tabulation does not accord with that specified by its authors for this cyst family and a reallocation may prove necessary in the future.

*Egmontodinium polyplacophorum* sp. nov.

Plate 8, figures 1-4; Plate 9, figure 3; Plate 11, figures 5-6, 8; text-figure 24

DERIVATION OF NAME: In reference to the large number of plates developed.

DIAGNOSIS: A species of *Egmontodinium* having an ovoidal cyst, thin walled and without prominent granulation or punctation. Sutures variably ornamented with delicate crests or with rows of spinelets, simple or bifurcate and sometimes distally connected; the sutural ornamentation is most prominent around the antapex. The tabulation is as for the genus, but shows some variation in detail through the presence or absence of additional small plates at sutural nodes.

HOLOTYPE: BM(NH) slide V.56360(2b), Kimmeridge Clay (Pectinatus Zone) 60 ft above Freshwater Steps Stone Band, Egmont Bight, Dorset. Paratypes: a. BM(NH) slide V.56360(1). b. BM(NH) slide V.56360(2a), showing apical archaeopyle. c. BM(NH) slide V.56347(1), also showing archaeopyle. [All paratypes are from the same locality and horizon as the holotype.]

DIMENSIONS: Holotype: length of cyst  $76\mu$ , breadth  $58\mu$ , maximum height of crests  $3.5\mu$ . Paratype a: length  $78\mu$ , breadth  $61.5\mu$ , maximum height of crests  $3\mu$ . Paratype b: length (apex lacking)  $68\mu$ , breadth  $59.5\mu$ , maximum height of crests c.  $5\mu$ . Paratype c: length (apex lacking)  $61\mu$ , breadth  $66\mu$ , maximum height of crests c.  $5.5\mu$ . Range: overall length  $60-80\mu$ , length without apex  $50-68\mu$ , breadth  $45-65\mu$ , maximum height of crests c.  $3-5\mu$ . Measured specimens: 15.

DESCRIPTION: The cyst surface is typically smooth, but may exhibit minute granulation or punctation. Ornament is normally confined to the sutures: in some instances, however, one or a few isolated spines, or a short row of spines not traversing the plate, may be present within a plate boundary.

Four apical plates are developed, the first being the largest and situated in the anterior prolongation of the sulcus. They are surrounded by six (possibly sometimes by only five) elongate plates constituting the anterior circle, plate 3ac being broader than the others in the holotype. The opercular suture opens along this circle, so that the plate boundaries with the apical plates are present in the operculum and those with the precingular plates on the cyst proper. The initial opening of the opercular suture appears to occur on the dorsal side: the operculum frequently retains a ventral attachment with the abandoned cyst. The holotype shows no opening: paratype (a) is partly open, though the operculum remains attached and almost in place; paratypes (b) and (c) lack the operculum.

The six precingular plates are almost of equal size. In the holotype, a small round plate is present at the node of the crest separating plates 3'' and 4'' and that bounding the operculum: no such plate was distinguished on the paratypes. The



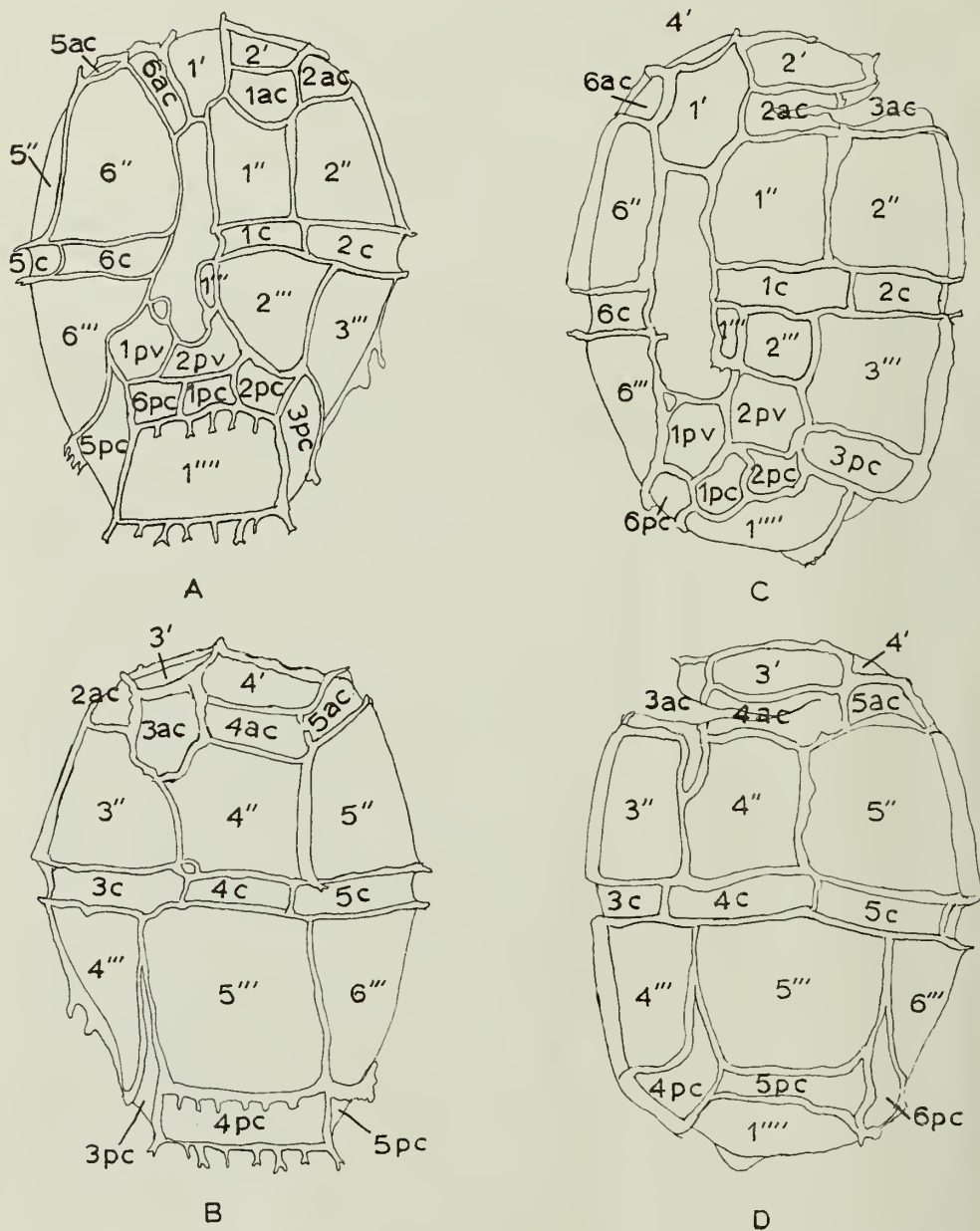


FIG. 24. *Egmontodinium polyplacophorum* gen. et. sp. nov. Reconstruction of the tabulation, A-B Holotype, BM(NH) slide V.56360 (2b) in ventral view and dorsal view. C-D Paratype (a), BM(NH) slide V.56360 (1) in ventral and dorsal view.  $\times$  c.958.



cingulum is made up of six elongate plates with clear boundaries. The sulcus is broad and occupies only the central part of the ventral surface, being separated from the apex by the large plate 1' and from the antapex by two posterior ventral plates and by two plates of the posterior circle. In the holotype, a small plate is present at the junction of the sulcus and plate 6'''.

Of the six postcingular plates, the first is extremely small (as is the case in many species of *Gonyaulacysta*) and may be masked by its bounding crests: plate 2''' is also reduced, to accommodate the second posterior ventral plate, an equivalent of the posterior intercalary plate but displaced to the ventral side. The other four post-tingular plates are quite large. The plates of the posterior circle are quite variable in form: in particular, plates 3pc and 5pc sometimes exhibit a remarkable "tail" extending along the sulcus separating two dorsal postcingular plates. The boundaries between the ventral posterior circle plates are in some instances distinguishable only with difficulty, if at all: the holotype is unusually clear in structure and exceptionally favourably orientated. The antapical plate is polygonal and quite large: on two specimens (paratypes a and c) it is partially subdivided by a row of proximally connected spines, but this row only traverses half the plate.

The ornamentation of the sutures is highly variable, from rows of isolated, simple or bifurcate spines, with or without distal or (more commonly) proximal connections, to simple delicate crests of moderate height. The highest crests are generally those bounding the cingulum and antapex. (The character of the crests may be modified by accidents of preservation.) The crests or spines are usually little more than one-tenth of the cyst breadth in height: difficulty is often experienced in distinguishing particular crests.

OBSERVED RANGE: Middle to Upper Kimmeridgian (*Wheatleyensis* to *Pectinatus* Zones).

Cyst-Family **PAREODINIACEAE** Gocht, emend. Sarjeant & Downie 1966

Genus **APTEODINIUM** Eisenack, 1958

*Apteodinium* cf. *maculatum* Eisenack & Cookson

Plate 12, figure 6

FIGURED SPECIMEN: I.G.S. slide PK.105, sample WB 4, from H.M. Geological Survey Borehole, Warlingham, at 2910 ft 6 in. depth. Lower Kimmeridgian (*Eudoxus* Zone).

DIMENSIONS: Figured specimen: overall length  $83\mu$ , breadth  $80\mu$ .

RANGE: (7 specimens measured): length  $50-83\mu$ , breadth  $45-80\mu$ , apical horn length  $3-4\mu$ . Range of the dimensions of Australian specimens, as given by Eisenack and Cookson: length  $74-105\mu$ , breadth  $70-105\mu$ . The Kimmeridgian specimens are thus of comparable size.

REMARKS: Nine specimens recorded, seven from English and two from French assemblages, are similar to *A. maculatum*, as recorded and described from the Albian by Eisenack and Cookson. They differ from the Australian specimens in

having a precingular archaeopyle and in the absence of the small thickened areas with circular outlines that give *A. maculatum* its characteristic appearance; in only one specimen, from the Warlingham assemblage, were similar small circular areas observed. The Kimmeridgian specimens must be thus considered only comparable to, and not definitely conspecific with, the Australian specimens.

OBSERVED RANGE: Lower to Middle Kimmeridgian (Baylei to Rotunda Zones). Not yet observed from the Cymodoce and Elegans Zones.

Genus **IMBATODINIUM** Vozzhennikova, 1967b

***Imbatodinium antennatum*** sp. nov.

Plate 11, figures 2-3

1970 *Imbatodinium* sp. Gitmez, 282, pl. 7, fig. 5, table 4.

DERIVATION OF THE NAME: Latin, *antenna*, feeler, a sensory appendage on the head of an insect—with reference to the similarity of the process rising up from the apical horn of this species to an insect's antenna.

DIAGNOSIS: A proximate cyst, elongate to ovoidal in shape, with a strong apical horn. On the distal end of the horn, there is a thread-like projection of variable length ending in a small knob. In some cases, a cingulum is weakly developed; but there is no indication of tabulation or sulcus. The surface of the cyst is granular. An intercalary archaeopyle is often developed.

HOLOTYPE: I.G.S. slide PK.124, sample WB 23, from H.M. Geological Survey Borehole, Warlingham, Surrey, at 2434 ft 6 in. depth. Middle Kimmeridgian (Hudlestoni Zone).

PARATYPE: BM(NH) slide V.56361(1), sample ED 242, from 60 ft above the Freshwater Steps Stone Band, Egmont Bight, Dorset. Upper Kimmeridgian (Rotunda Zone).

DIMENSIONS: Holotype: overall length  $73\mu$ , breadth  $35\mu$ , apical horn length without projection  $9\mu$ , with projection  $16\mu$ . Range of the observed specimens (16 in number): overall length 62-100 $\mu$ , breadth 28-50 $\mu$ , overall length of horn 12-30 $\mu$ , horn length without projection 7-16 $\mu$ , length of the projection 4-14 $\mu$ .

DESCRIPTION: The cyst is elongate, broadening in the posterior median region. The apical horn is well developed, bearing a thread-like process of variable length, generally between half and one-third of the overall horn length. This thread-like process ends in a small bulge, which appears as a knob. The cingulum is only weakly developed, but may be suggested by faint surface marking. The epitract is longer than the hypotract, comprising almost two-thirds of the overall length.

OBSERVED RANGE: Lower to Upper Kimmeridgian (Baylei to Rotunda Zones). Not yet observed from the Cymodoce and Elegans Zones.

REMARKS: This new species of *Imbatodinium* is distinguished from the previously described species in its general shape, presence of an intercalary archaeopyle and

characteristic shape of the apical horn. In horn shape, it is similar to *I. villosum*, which was recorded from the Upper Jurassic of Russia by Vozzhennikova, but it differs from *I. villosum* in the absence of the sutural spines distributed all over the surface.

*I. antennatum* is present in the Kimmeridgian assemblages of England, Scotland and France; however, it is infrequent; one specimen from France, one specimen from Scotland and fifteen specimens from England being recorded. It is rare in the Lower Kimmeridgian, in which only four specimens were observed. The number increases in the upper horizons: five specimens were recorded from the Middle Kimmeridgian and seven specimens from the Upper Kimmeridgian.

*Imbatodinium* cf. *villosum* Vozzhennikova, 1967b

Plate II, figure 1

DESCRIPTION: The cyst is broadly ovoidal, elongate, with a broad based apical horn, distally bearing a process. There is neither tabulation nor sulcus; the cingulum is only faintly indicated. The epitract is longer than the hypotract, comprising almost three-quarters of the whole length of the cyst. The surface of the cyst is coarsely granular and covered by short, thick spines. An archaeopyle, intercalary in position, is occasionally present.

FIGURED SPECIMEN: BM(NH) slide V.56362(1), sample HC 243, from c. 100 ft below the Rotunda Nodules Bed, Chapmans Pool, Dorset. Upper Kimmeridgian (Pectinatus Zone).

DIMENSIONS: Figured specimen: overall length  $80\mu$ , breadth  $40\mu$ , horn length  $17\mu$ . Range: overall length  $70-87\mu$ , breadth  $40-52\mu$ , overall length of horn  $8-17\mu$ , horn length without process  $4-13\mu$ , apical process length  $4-6\mu$ ; length of the spines over the surface  $2.5-4\mu$ . Dimensions of *I. villosum* as given by Vozzhennikova: overall length  $70.5-100\mu$ , breadth  $27-40.5\mu$ , apical horn length  $10.5-13.5\mu$ .

REMARKS: Seven specimens observed in the Upper Kimmeridgian (Pectinatus to Pallasioides Zones) assemblages of England are similar to *I. villosum*, but smaller and the spines distributed on the surface are relatively shorter; for these reasons, they are compared with, rather than attributed to *I. villosum*. Vozzhennikova recorded this species from the Upper Jurassic of the Moscow Province, U.S.S.R.

Cyst-family UNCERTAIN

Proximate cyst sp. indet.

Plate II, figures 4, 7, 9

DESCRIPTION: The shell is broadly ovoidal to subspherical, with two blunt apical horns; the apex is rounded. Tabulation is very faintly indicated; four apical plates, six precingular and one antapical plate were determined with difficulty. The cingulum is indicated by inbulges on the sides of the cyst; the sulcus was not observed. The epitract is longer than the hypotract, so far as is determinable from

the feeble indications of the cingulum. The archaeopyle is well developed, but in a very different way from the observed archaeopyle types in recorded species: the apex as a whole, together with one of the precingular plates, is thrown off in the archaeopyle formation, though the apex remains attached to the cyst. The surface of the cyst is densely granular; irregularly formed lumps (verrucae) were present on three of the observed specimens.

FIGURED SPECIMENS: BM(NH) slide V.56363(1) and V.56364, sample FD 236, from  $\frac{1}{4}$  mile west of Freshwater Steps, Dorset. Middle Kimmeridgian (from the boundary of the Pectinatus and Hudlestoni Zones).

DIMENSIONS: Range of the observed specimens (4 in number): overall length 66–83 $\mu$ , breadth 60–75 $\mu$ .

REMARKS: Four specimens were observed, in the English Middle and Upper Kimmeridgian assemblages (Wheatleyensis to Rotunda Zones). In its mode of archaeopyle formation, this form is different from all previously described proximate cysts. Because of the bad preservation and dense surface ornamentation, full details of the morphology could not be obtained; in consequence, no new taxon is proposed.

Cyst-Family **ADNATOSPHAERIDIACEAE** Sarjeant and Downie, 1966

Genus **ADNATOSPHAERIDIUM** Williams & Downie, 1966

***Adnatosphaeridium paucispinum*** Klement, 1960b, comb. nov.

Plate 10, figures 1–4

1960 *Cannosphaeropsis paucispina* Klement, 72, pl. 10, figs 9–10.

1964 *C. paucispina* Klement; Downie & Sarjeant, 101.

1964 *C. paucispina* Klement; Sarjeant, table 3.

DESCRIPTION: Cyst subspherical to ovoidal in shape, with a thin, smooth shell wall bearing slender, hollow processes, open distally and branched or broad, funnel-shaped, fenestrate. The processes are connected distally by trabeculae. An apical archaeopyle with a zig-zag margin was seen in almost all observed specimens.

FIGURED SPECIMENS: BM(NH) slide V.56365(1) and V.56366(2), sample BN 179, from the Cymodoce Zone of Benerville, Normandy.

DIMENSIONS: Range (8 specimens were measured): length 40–55 $\mu$ , breadth 35–60 $\mu$ , length without apex (6 of the measured specimens have apical archaeopyles) 30–50 $\mu$ , process length 15–30 $\mu$ .

OBSERVED RANGE: Lower to Middle Kimmeridgian (Cymodoce to Hudlestoni/Pectinatus boundary).

TOTAL KNOWN RANGE: Upper Oxfordian (Malm Alph.) to Middle Kimmeridgian (Hudlestoni/Pectinatus Boundary).

REMARKS: This species has previously been recorded from the Upper Oxfordian of Germany by Klement (1960). It is now placed in the genus *Adnatosphaeridium* on the basis of the presence of an apical archaeopyle. The observed specimens



were recorded from the Lower Kimmeridgian (Cymodoce Zone) of Normandy and Middle Kimmeridgian (Boundary of Hudlestoni and Pectinatus Zones) of Dorset.

Cyst-Family **HYSTRICHOSPHAERIDIACEAE** Evitt, emend. Sarjeant and Downie, 1966

Genus **CLEISTOSPHAERIDIUM** Davey, Downie, Sarjeant and Williams, 1969

*Cleistosphaeridium* sp.

Plate 15, figure 3

DESCRIPTION: The cyst is spherical to subspherical, the wall thin and granular. Transparent processes, approximately 60 in number, are present: they are simple, conical, hollow and closed distally; their length is generally less than one-third of the cyst length. An apical archaeopyle is sometimes developed.

FIGURED SPECIMEN: BM(NH) slide V.56367(1), sample ED 242, from 60 ft above the Freshwater Steps Stone Band, Dorset. Upper Kimmeridgian (Pectinatus Zone).

DIMENSIONS: Figured specimen: Cyst length (apex lacking) 50 $\mu$ , breadth 50 $\mu$ , process length 12 $\mu$ . Range (16 specimens measured): cyst length 38–60 $\mu$ , length without apex 40–50 $\mu$ , breadth 38–66 $\mu$ , length of the processes 10–22 $\mu$ .

OBSERVED RANGE: Lower to Upper Kimmeridgian (Autissiodorensis to Rotunda Zones). Not yet observed from the Scitulus-Hudlestoni Zones.

REMARKS: Although quite a number of specimens (31 in number) were recorded, the preservation was consistently very bad: they were always found covered by debris, so that there was no chance to examine them in detail sufficient to justify giving a specific name. They accord in general appearance, number and type of processes and apical archaeopyle, with the genus *Cleistosphaeridium*. The most similar species is perhaps *C. machaerophorum* Deflandre and Cookson (1955), which was recorded from the Miocene of Australia, but the bad preservation precluded any detailed study.

Genus **OLIGOSPHAERIDIUM** Davey and Williams, 1966

*Oligosphaeridium pulcherrimum* (Deflandre and Cookson) Davey and Williams, 1966

Plate 13, figure 3, text-figure 25

- 1954 *Hystrichosphaeridium pulcherrimum* Deflandre & Cookson, text-fig. 6, *nomen nudum*.
- 1955 *H. pulcherrimum* Deflandre & Cookson, 270, pl. 1, fig. 8, text-fig. 21.
- 1955 *H. pulcherrimum* Deflandre & Cookson; Valensi, 592, pl. 4, fig. 1.
- 1957 *H. pulcherrimum* Deflandre & Cookson; Delcourt & Sprumont, 59, pl. 1, fig. 4, pl. 2, fig. 12.
- 1964 *H. pulcherrimum* Deflandre & Cookson; Downie & Sarjeant, 121.
- 1966 *Oligosphaeridium pulcherrimum* (Deflandre & Cookson); Davey & Williams, 75–6, pl. 10 fig. 9, pl. 11, fig. 5; table 1.
- 1967b *O. pulcherrimum* (Deflandre & Cookson); Sarjeant, table 6.



- 1967 *Hystrichosphaeridium pulcherrimum* Deflandre & Cookson; Clarke and Verdier, 54-5  
pl. 10, figs 4-5.  
1970 *Oligosphaeridium pulcherrimum* (Deflandre & Cookson); Gitmez, 290 pl. 7, fig. 7, table 4.

DESCRIPTION: The subspherical cyst possesses processes of two types. Some processes are tubular, distally open, widening distally and assuming a funnel shape with fenestrate walls (characteristic for this species); the other processes are simple, bifid or foliate. Because of the complication of the processes and bad preservation, accurate determination of the reflected tabulation was not possible, but the tabulation 6'', 5''', 1p, 2''', 3s may be suggested, with five additional simple processes that could not be named and appear random in distribution. The surface of the shell is smooth. Apical archaeopyle developed.

FIGURED SPECIMEN: BM(NH) slide V.56368(1), sample CC 449, from c. 10 ft from the top of the Calcaires du Moulin Wibert, Cap de la Crèche, Boulonnais. Lower Kimmeridgian (Baylei Zone).

DIMENSIONS: Figured specimen: length (apex lacking) 40 $\mu$ , breadth 50 $\mu$ , process length 25–28 $\mu$ . Range (4 specimens observed): length (apex lacking) 35–48 $\mu$ , breadth 45–55 $\mu$ , process length 18–35 $\mu$ . Dimensions of the holotype: overall diameter c. 118 $\mu$ , process length 26–38 $\mu$  (as quoted by Deflandre and Cookson).

REMARKS: This species first recorded from the Jurassic by Gitmez (1970). Unfortunately, all specimens observed are in too poor condition for examination in detail. Four specimens were recorded, all from the Lower Kimmeridgian (Baylei Zone) assemblages, two of them from Dorset and two from France.

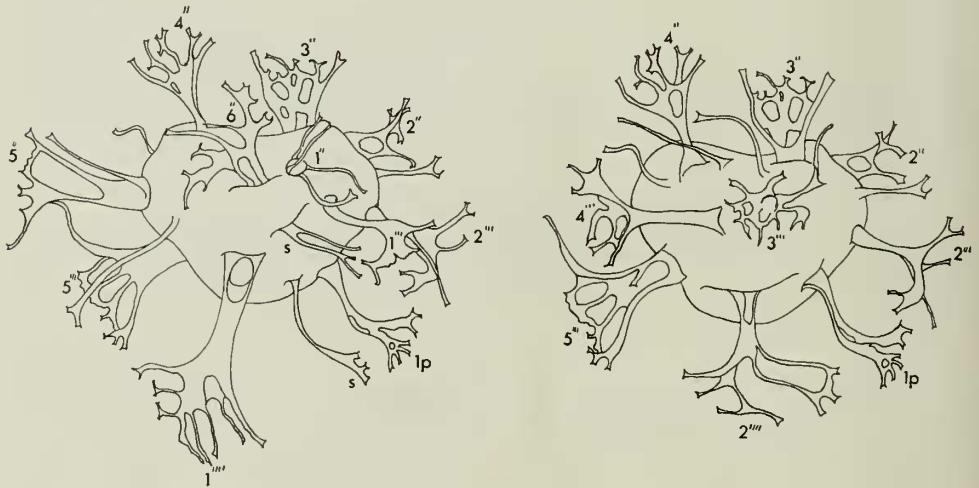


FIG. 25. *Oligosphaeridium pulcherrimum* (Deflandre & Cookson). Specimen showing the suggested tabulation: left, in ventral view; right, in dorsal view. BM(NH) slide V.56368 (1).  $\times$  c.643.

Genus **SYSTEMATOPHORA** Klement, 1960b

***Systematophora ovata* sp. nov.**

Plate 14, figures 1-3

1970 *Systematophora* sp. Gitmez, 296, pl. 8, fig. 5, table 4.

DERIVATION OF THE NAME: Latin, *ovatus*, egg-shaped, with reference to the shape of the cyst.

DIAGNOSIS: A species of *Systematophora* having an elongate, ovoidal cyst bearing short processes (not more than one-fourth of the cyst breadth). The processes are located in groups: there are ten such groups, one occupying the apex, an opposite one the antapex, whilst eight groups are distributed between the apex and the antapex, four of them on the epitract, the other four on the hypotract. There is no connection between the groups of processes or between the processes in each group. The processes are simple, bifid distally or broad based, foliate and deeply forked at their distal end. The surface of the shell is finely granular. When an archaeopyle is developed, it is apical in position.

HOLOTYPE: BM(NH) slide V.53962(1), sample SC 444, from the Great Ouse River Board Pit, Stretham, Cambridgeshire. Lower Kimmeridgian (Baylei Zone).

PARATYPE: BM(NH) slide V.56343(2), sample HC 243, from c. 100 ft below the Rotunda Nodules, Hounstout Cliff, Dorset. Upper Kimmeridgian (Pectinatus Zone).

DIMENSIONS: Holotype: shell length (apex lacking) 35 $\mu$ , breadth 28 $\mu$ , process length 6-8 $\mu$ . Paratype: shell length 58 $\mu$ , breadth 40 $\mu$ , process length 8 $\mu$ . Range: shell length 58-60 $\mu$ , apex lacking 35-48 $\mu$ , breadth 28-45 $\mu$ , process length 8-11 $\mu$ . Measured specimens were 6 in number.

DESCRIPTION: The cyst wall is composed of two layers, the periphragm forming the processes. Both of the layers are thin and transparent. There is no connection between the processes at their proximal and distal ends; they arise separately from each other, positioned around the margins of ovoidal or polygonal fields whose shape is clearly shown by the broad bases of the processes.

REMARKS: This new species was observed very infrequently in the Lower and Upper Kimmeridgian: one specimen was recorded from the Baylei Zone, three specimens from the Pectinatus Zone and one specimen from the Pallasioides Zone of England. Only one specimen was observed in the Scottish assemblages and none from France. The preservation of the specimens was moderately good. This new species differs from all previously described species of the genus on the basis of shape and character of its processes, in combination with the shape of the cyst.

Cyst-Family **UNCERTAIN**

Genus **STEPHANELYTRON** Sarjeant, 1961a

***Stephanelytron redcliffense* Sarjeant, 1961a**

Plate 14, figure 6

- 1960c Organism A. Sarjeant, 404, pl. 13, fig. 13, table 2.  
1961a *Stephanelytron redcliffense* Sarjeant, 109-110, pl. 15, fig. 11, text-figs 10, 15.  
1962a *S. redcliffense* Sarjeant; Sarjeant, table 4.  
1962b *S. redcliffense* Sarjeant; Sarjeant, 495, pl. 70, fig. 7, tables 2-3.  
1964 *S. redcliffense* Sarjeant; Downie and Sarjeant, 146.  
1964 *S. redcliffense* Sarjeant; Sarjeant, table 4.  
1967 *S. redcliffense* Sarjeant; Brito, pl. 2, fig. 3.  
1968b *S. redcliffense* Sarjeant; Sarjeant, 225, pl. 3, fig. 5, table 2A.

DESCRIPTION: The cyst is broadly ovoidal, rounded at both ends. The tubular processes extend down the flanks in six rows and surround the apex and antapex in transverse rows; there is also a median transverse row of processes. A corona, broad-based and bearing striations, is present on the antapex. The cyst wall is composed of two layers; both are thin and transparent, without ornamentation. The periphragm forms the processes. There is no connection between the central cavity and the cavity of processes. An apical archaeopyle is typically developed.

FIGURED SPECIMEN: BM(NH) slide V.56366(1), sample BN 179, from the Cymodoce Zone of Benerville, Normandy.

DIMENSIONS: Figured specimen: cyst length  $40\mu$ , breadth  $32\mu$ , process length  $5\mu$ , corona length  $8\mu$ . Range: length  $40-60\mu$ , length (apex lacking)  $45-50\mu$ , breadth  $32-45\mu$ , process length  $4-5\mu$ , corona length  $5-8\mu$ . Measured specimens 4 in number. Holotype dimensions, as given by Sarjeant: length  $36\mu$ , breadth  $30\mu$ , process length  $5\mu$ , corona length  $10\mu$ . The Kimmeridgian specimens exhibit similar dimensions, except in the length of the corona, which is greater in the holotype.

REMARKS: This species was originally recorded from the Oxford Clay of England, and later from the Lower Oxfordian of Normandy, by Sarjeant (1961, 1968). Five specimens, all from the same horizon in the Cymodoce Zone of Normandy, were observed, which are closely similar to those figured by Sarjeant.

### *Stephanelytron* cf. *redcliffense* Sarjeant, 1961a

#### Plate 14, figure 7

DESCRIPTION: Two specimens, also from the Cymodoce Zone, show a general resemblance to *S. redcliffense* but differ in that the processes are markedly thinner. Forms of intermediate character were not encountered.

FIGURED SPECIMEN: BM(NH) Slide V.56365(2), sample BN 179 from the Cymodoce Zone of Benerville, Normandy.

DIMENSIONS: Figured specimen: cyst length (apex lacking)  $35\mu$ , breadth  $30\mu$ , process length  $5\mu$ , corona length  $7\mu$ . The second specimen could not be measured because of its bad preservation and orientation.

REMARKS: These two specimens from the Lower Kimmeridgian (Cymodoce Zone of France) may represent a new species or might be extremes in the range of morphological variation of *S. redcliffense*. Fuller information must be awaited.

Cyst-Family **ENDOSCRINIACEAE** Vozzhennikova, emend. Sarjeant and Downie, 1966

Genus **ENDOSCRINIUM** Klement, 1960b emend. Vozzhennikova, 1967a

*Endoscrinium* sp.

Plate 14, figures 9–11, text-figure 26

**DESCRIPTION:** A species of *Endoscrinium* possessing a subspherical to broadly ovoidal periblast, without apical or antapical horns. The periphragm is irregularly studded with pores of varying shapes and sizes; the endophragm is finely granular. The sutural crests are well defined, in the form of low ridges. Reflected tabulation: 4', 6'', 6c, 5''', 1p, 1pv, 1''' and 8s. Plate 1' is elongate, plates 2' and 3' are relatively small, the boundary between them was not confirmed; plate 4' is quite large. The precingular plates and postcingular plates are large, plate 3''' being the largest of all the plates. The cingulum is strongly laevorotatory, occupied by six plates; plates 1c and 6c are greatly reduced, the other cingular plates are of constant size. The cingulum divides the cyst more or less equally. The sulcus is broad, occupied by sulcal plates of varying shape and size.

A precingular archaeopyle is developed, and formed by loss of plate 3''.

**FIGURED SPECIMEN:** BM(NH) slide V.56369(1), sample OF 485, from well-bedded calcilutite, Montard d'Oignon, France. Lower Kimmeridgian (Mutabilis Zone).

**DIMENSIONS:** Figured specimen: overall length 78 $\mu$ , breadth 75 $\mu$ , endoblast length 60 $\mu$ , breadth 55 $\mu$ .

**REMARKS:** Only one well preserved specimen has so far been observed. The

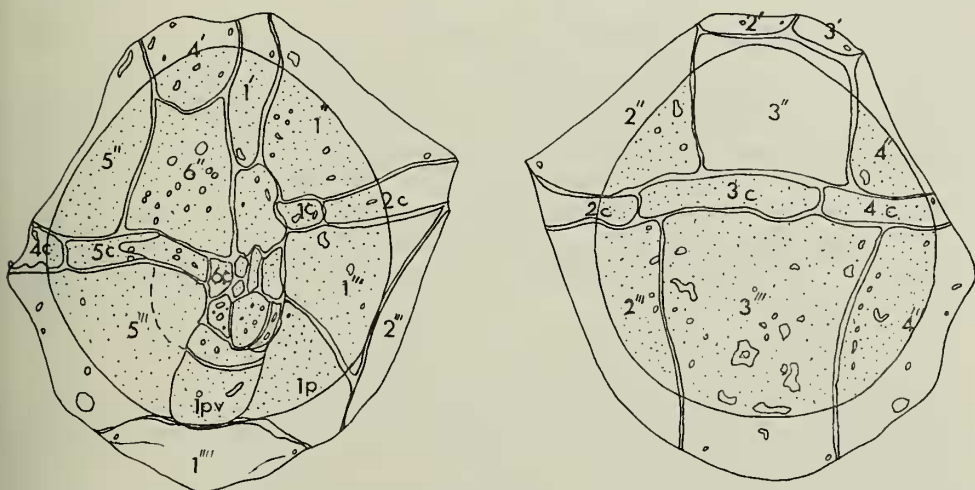


FIG. 26. *Endoscrinium* sp. Tabulation and the archaeopyle formation: left, in ventral view; right, in dorsal view. Specimen BM(NH) slide V.56369 (1).  $\times$  c.836.



perforation of the periblast and the presence of sulcal plates distinguish this species from all described forms. The general appearance of the cyst and the tabulation are most comparable to *E. luridum*, suggesting a relationship between two species.

Cyst-Family **HEXAGONIFERACEAE** Sarjeant & Downie, 1966

Genus **HEXAGONIFERA** Cookson and Eisenack, 1961a emend. Cookson and Eisenack, 1962

*Hexagonifera jurassica* sp. nov.

Plate 14, figures 5, 8

1970 *Hexagonifera* sp. Gitmez, 2, pl. 1, fig. 12, table 4.

DERIVATION OF THE NAME: So named because this is the first species of the genus observed in Jurassic assemblages.

DIAGNOSIS: A species of *Hexagonifera* with broadly ovoidal to elongate cyst. The periblast has a blunt, hollow apical projection formed by the periphragm only. The surface of the periblast is delicate, smooth or minutely granular: the endoblast, in contrast, is thick-walled and densely granular, with occasional tubercles. A circular cingulum divides the periblast almost equally; sometimes the epittract is slightly smaller than the hypotract. There is no definite indication of tabulation or of a sulcus. An apical archaeopyle is typically developed.

HOLOTYPE: I.G.S. slide PK.123, sample WB 20, from H.M. Geological Survey Borehole, Warlingham, at 2510 ft depth. Middle Kimmeridgian (Wheatleyensis Zone).

PARATYPE: BM(NH) slide V.53621(1), sample SS 627, from 100 ft above the second dolerite sill, Staffin Bay, Skye. Lower Kimmeridgian (Baylei Zone).

DIMENSIONS: Holotype: overall length 85 $\mu$ , breadth 72 $\mu$ , endoblast length 73 $\mu$ , breadth 66 $\mu$ , Paratype: overall length (apex lacking) 46 $\mu$ , breadth 50 $\mu$ , endoblast length (apex lacking) 40 $\mu$ , breadth 42 $\mu$ . The size range of specimens from different horizons is shown in Table 1; according to these measurements, the Lower Kimmeridgian specimens are smaller than those from the Middle and Upper Kimmeridgian. (There is only a slight size difference between the Middle and Upper Kimmeridgian specimens). No dimensional difference was observable between the English and French specimens.

OBSERVED RANGE: Lower to Upper Kimmeridgian (Baylei to Pallasioides). Not yet observed from the Cymodoce, Mutabilis, Elegans and Scitulus Zones.

DESCRIPTION: The subspherical to ovoidal endoblast is completely enclosed by the delicate periblast. The epittract of the periblast is conical, with no apical projection superimposed on the cone shape. The epittract of the endoblast is rounded and dome-shaped. The antapex of both periblast and endoblast is rounded. A polygonal apical archaeopyle is usually present; generally the operculum remains attached to the shell. The tabulation is generally indeterminable, but the dorsal tabulation



could be distinguished with difficulty on some specimens: two apical, three pre-cingular, three postcingular and one antapical plates were recognised.

REMARKS: This new species is distinguished from previously described species of the genus by the presence of a cingulum and poorly developed tabulation.

These specimens are similar to *H. chlamydata* Cookson & Eisenack, (1952) in having a granular endoblast, but it is impossible to compare the periblast since it is usually badly preserved or not preserved at all. The presence of a slight apical prominence, a cingulum and poorly developed tabulation distinguish this species from *H. chlamydata*.

TABLE 2

Range of the dimensions of *Hexagonifera jurassica* from the different levels of the Kimmeridgian

	Lower Kimmeridgian	Middle Kimmeridgian	Upper Kimmeridgian
Periblast:			
Length	45-50 $\mu$	70-102 $\mu$	80-105 $\mu$
Length without apex	42-55 $\mu$	60-75 $\mu$	55-70 $\mu$
Breadth	35-56 $\mu$	58-90 $\mu$	50-90 $\mu$
Endoblast:			
Length	40-48 $\mu$	58-88 $\mu$	65-90 $\mu$
Length without apex	38-59 $\mu$	55-75 $\mu$	45-65 $\mu$
Breadth	35-52 $\mu$	58-75 $\mu$	45-75 $\mu$
Measured specimens	12	29	19

Cyst-Family **MUDERONGIACEAE** Neale & Sarjeant, emend. Sarjeant & Downie, 1966

Genus **MUDERONGIA** Cookson & Eisenack, 1958

*Muderongia simplex* Alberti, 1961

Plate 15, figures 1-2

1961 *Muderongia simplex* Alberti, 12, pl. 2, figs 1-6, pl. 12, figs 1-2, table c.

1964 *M. simplex* Alberti; Downie & Sarjeant, 134.

1964 *M. simplex* Alberti; Eisenack, 525-6.

1966b *M. simplex* Alberti; G. & M. Deflandre, fiches 3249-50.

1967b *M. simplex* Alberti; Sarjeant, table 12.

DESCRIPTION: The cyst is flattened, bearing an apical, two lateral and two antapical horns. Its outline is almost rhombic, as a result of differential development of the horns. The lateral horns are short and rounded at their free end. The antapical horns are unequal in length; one of them is very short and blunt, the other is well developed. The endoblast lies close to the outer margin of the periblast, generally stretching out into the horns but not reaching their tips, so that lateral,

apical and antapical pericoels are present. The tabulation is not well indicated but lines on the epitract, observable only with difficulty, simulate plate boundaries. A narrow cingulum is present but poorly marked. Both periphragm and endophragm are transparent; the surface of the periblast is granular. A well-developed apical archaeopyle was observed in one of the specimens; the other specimens observed often have a split on the flank of the apical region, indicating that the archaeopyle has not developed fully.

FIGURED SPECIMENS: I.G.S. slides PK.128 and PK.129, sample WB 29, from H.M. Geological Survey Borehole, Warlingham, Surrey, at 2285 ft 7 in. depth. Upper Kimmeridgian (Rotunda Zone).

DIMENSIONS: Range of the observed specimens (11 in number): overall length 78–110 $\mu$ , breadth 68–90 $\mu$ , endoblast length 65–88 $\mu$ , breadth 55–75 $\mu$ , overall length (without apex) 70 $\mu$ , endoblast length (without apex) 48 $\mu$ . Alberti gave the following ranges from Cretaceous specimens of the species: overall length 68–175 $\mu$ , breadth 63–133 $\mu$ .

REMARKS: *M. simplex* has been recorded from Valanginian to Barremian of Poland, Bulgaria and Germany. Eleven specimens were recorded, for the first time from England and the Jurassic, all from one horizon, the Rotunda Zone of the Warlingham Borehole. These specimens are similar to the specimens figured by Alberti, the only difference being that the apical horn is not so long as the apical horn of previously recorded specimens and the notches at the ends of the lateral horns were not seen on the Kimmeridgian specimens. With its second, blunt antapical horn, *M. simplex* is similar to the type species of the genus, *M. mcwhaei*, but it differs in its short and rounded-ended lateral horns, whereas those of the type species are long and curved, downwardly directed.

Cyst-Family NELSONIELLACEAE Eisenack, emend. Sarjeant & Downie, 1966

Genus *SCRINIODINIUM* Klement, 1957

*Scriniodinium bicuneatum* (Deflandre) Sarjeant, 1967a

Plate 15, figure 4

- 1938 *Palaeoperidinium bicuneatum* Deflandre, 180, pl. 8, fig. 7.
- 1957 *P. bicuneatum* Deflandre; Downie, 422, pl. 20, fig. 2, table 1.
- 1964 *P. bicuneatum* Deflandre; Downie & Sarjeant, 137.
- 1964 *P. bicuneatum* Deflandre; Eisenack, 591–2.
- 1964 *P. bicuneatum* Deflandre; Sarjeant, table 2.
- 1967a *Scriniodinium bicuneatum* (Deflandre); Sarjeant, 248.
- 1967b *S. bicuneatum* (Deflandre); Sarjeant, table 11.
- 1970 *S. bicuneatum* (Deflandre); Gitmez, 308, pl. 5, fig. 5, table 4.

OBSERVED RANGE: Lower to Upper Kimmeridgian (Baylei to Pallasioides). Not yet recorded from the Elegans and Scitulus Zones.

TOTAL KNOWN RANGE: Oxfordian (prob. Cordatum)—Kimmeridgian (Rotunda).

FIGURED SPECIMENS: BM(NH) slide V.56370, sample MR 547, from the lower

boundary of the Platynota Zone (Baylei Zone), west side of the Ravin d'Enfer, Crussol, France.

**DIMENSIONS:** Range: overall length 80–115 $\mu$ , breadth 65–100 $\mu$ , endoblast length 75–90 $\mu$ , breadth 62–83 $\mu$ . (Measured specimens 36 in number). Holotype dimensions, as given by Deflandre, are 100 $\mu$  length, 65 $\mu$  breadth, well within the quoted range.

**REMARKS:** *S. bicuneatum* was originally recorded from the Oxfordian of Normandy; the species was based on a single specimen which was not well preserved. In 1957, it was, for the first time, observed in the English assemblages, when Downie recorded it from the Pectinatus Zone of Dorset. His specimens also were poorly preserved.

It is abundantly present in the Kimmeridgian samples examined from England (55 specimens being recorded); but rare in Scottish and French assemblages (5 specimens from the Baylei Zone of France and only one from the Cymodoce Zone of Scotland). The preservation was generally not good. The presence or absence of an endoblast was not confirmed by Deflandre, nor later by Sarjeant, who re-examined the holotype, noted the general similarity to the members of *Scriniodinium* and redesignated this species as *S. bicuneatum*: its presence can now be confirmed.

The authors consider that Deflandre's figures are in an inverse orientation, with antapex uppermost. The figured specimen is shown in the correct orientation: the ventral tabulation is not discernible, but apical, pre- and postcingular plate series can be distinguished without difficulty.

### *Scriniodinium dictyotum* Cookson & Eisenack, 1960a

Plate 15, figures 5–7, Plate 16, figure 6; text-figure 27

- 1960a *Scriniodinium dictyotum* Cookson & Eisenack; 248–9, pl. 37, figures 8, 9.
- 1962a *S. dictyotum* Cookson & Eisenack: Sarjeant, 262, pl. 1, fig. 9, tabs 3–4.
- 1962b *S. dictyotum* Cookson & Eisenack: Sarjeant, pl. 69, fig. 11.
- 1964 *S. dictyotum* Cookson & Eisenack: Downie & Sarjeant, 145.
- 1964 *S. dictyotum* Cookson & Eisenack: Eisenack, 755.
- 1964a *S. dictyotum* Cookson & Eisenack: Sarjeant, table 2.
- 1967 *S. dictyotum* Cookson & Eisenack: Sarjeant, table 11.
- 1968 *S. dictyotum* Cookson & Eisenack: Sarjeant, 236, pl. 1, fig. 7, table 2b.
- 1970 *S. dictyotum* Cookson & Eisenack: Gitmez, 310.
- 1970 *S. dictyotum* subsp. *dictyotum* Cookson & Eisenack: Gitmez, 310.
- 1970 *S. dictyotum* subsp. *osmingtonensis* Gitmez, 310–11, pl. 1, fig. 3, pl. 8, fig. 12.
- 1970 *S. dictyotum* subsp. *papillatum* Gitmez, 311, pl. 9, fig. 11.
- 1970 *S. dictyotum* subsp. *pyrum* Gitmez, 311–13, pl. 13, figs 1–2, pl. 10, figs 1: Text-fig. 33a–b.

**REMARKS:** A text-figure clarifying the differences (in form of the apex) between the four subspecies distinguished by Gitmez (1970) is here presented. The typical subspecies, *S. dictyotum dictyotum*, was not encountered in the basal Kimmeridgian, although recorded by Sarjeant (1962a, 1962b, 1964a, 1967b) from the Oxfordian of England and France: four specimens were, however, obtained from the Pectinatus Zone (specimen ED 240) of Dorset. The other subspecies were found only in the Lower Kimmeridgian: observed ranges:

*S. dictyotum osmingtonensis* Baylei only: Dorset.

*S. dictyotum papillatum* Baylei to Mutabilis: Dorset and France.

*S. dictyotum pyrum* Baylei only: Dorset and France.

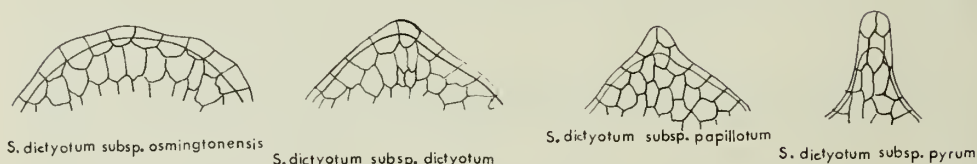


FIG. 27. *Scriniodinium dictyotum* (Cookson & Eisenack). Diagram showing the variation in the character of the apex in the four subspecies of the above.

### *Scriniodinium* sp.

#### Plate 13, figure 4

**DESCRIPTION:** The periblast is broadly ovoidal, with a hollow apical horn and rounded antapex. The surface of the periblast is smooth. The endoblast is subspherical to elongate, with rounded ends; its surface is smooth or minutely granular. Boundaries of reflected plates were indicated very feebly or not at all; in consequence, the tabulation could not be determined. The cingulum is relatively narrow and slightly helicoid, laevorotatory. A broad sulcus could be distinguished on some of the specimens observed. No archaeopyle was seen.

**FIGURED SPECIMEN:** I.G.S. slide PK.107, sample WB 7 from H.M. Geological Survey Borehole, Warlingham, Surrey, at 2834 ft 7 in. depth. Lower Kimmeridgian (Eudoxus Zone).

**DIMENSIONS:** Figured specimen: periblast length  $105\mu$ , breadth  $76\mu$ , endoblast length  $80\mu$ , breadth  $70\mu$ . Range: overall length  $53-105\mu$ , breadth  $42-76\mu$ , endoblast length  $42-80\mu$ , breadth  $35-70\mu$ . Measured specimens 5 in number.

**OBSERVED RANGE:** Lower to Upper Kimmeridgian (Mutabilis to Pectinatus).

**REMARKS:** Six specimens [two from the Lower Mutabilis, two from the Middle (Scitulus) and two from the Upper (Pectinatus) Kimmeridgian], all from English assemblages, were recorded. In general appearance, they are similar to *Dingodinium europaeum*, which was recorded from the Aptian of Germany by Eisenack (1958c). However, these specimens are larger; Eisenack did not record specimens over  $65-67\mu$  length. Since there is a very considerable stratigraphic gap and also a difference in dimensions, and in the absence of data regarding the archaeopyle, they were not placed in *D. europaeum* but were assigned to the genus *Scriniodinium*.



Genus *SIRMIODINIUM* Alberti, 1961*Sirmiodinium grossi* Alberti, 1961

## Plate 16, figures 7-8

1961 *Sirmiodinium grossi* Alberti, 22, pl. 7, figs 5-7, pl. 12, fig. 5; table c.

1964 *S. grossi* Alberti; Downie & Sarjeant, 145.

1965 *S. grossi* Alberti; G. & M. Deflandre, fiches 2787-2788.

1966 *S. grossi* Alberti; Sarjeant, p. 212, pl. 22, fig. 7, table 5.

1967b *S. grossi* Alberti; Sarjeant, table 11.

**DESCRIPTION:** The cyst is dorso-ventrally flattened. The periblast is roughly pentagonal in shape, with a blunt apical horn and flattened antapex. The endoblast is subspherical to ovoidal, both ends rounded. The circular cingulum is very deep and divides the cyst unequally; the epitract is smaller than the hypotract. The tabulation is poorly indicated; on the dorsal side of the cyst, two apical, three precingular and three postcingular plates were recognised, but the ventral tabulation was not established. The surface of the endoblast is apparently smooth, the surface of the periblast minutely granular. In one of the five specimens observed, an apical archaeopyle was observed, formed by loss of the whole apex; in the other specimens, the apex is still attached to the shell in the position of the first apical plate and a median dorsal, precingular plate (possibly 3'') is also surrounded by splits, suggesting that a combination archaeopyle of an undescribed type is developed. In all the observed specimens there is a posterior dorsal aperture of circular shape.

**FIGURED SPECIMENS:** BM(NH) slide V.56373(1) and V.56374(1), sample CP 245, from the Rotunda Nodule Bed, Chapmans Pool, Dorset. Upper Kimmeridgian (Rotunda Zone).

**DIMENSIONS:** Range: overall length 65-80 $\mu$ , length without apex 48 $\mu$ , breadth 48-70 $\mu$ , endoblast length 59-70 $\mu$ , without apex 43 $\mu$ , breadth 40-60 $\mu$ . Measured specimens 5 in number. Holotype: overall length 91 $\mu$ , breadth 86 $\mu$ , endoblast length 72 $\mu$ , breadth 61 $\mu$ , as given by Alberti.

**OBSERVED RANGE:** Upper Kimmeridgian (Rotunda Zone).

**TOTAL KNOWN RANGE:** Upper Kimmeridgian (Rotunda Zone) to Upper Barremian.

**REMARKS:** Five specimens were observed, all from the same horizon in Dorset. These specimens are characterized by their archaeopyle formation and their posterior dorsal aperture. Alberti (1961) recorded the holotype from the Upper Hauterivian to Upper Barremian of Germany, Sarjeant (1966) encountered it also in the Lower Hauterivian. Its presence also in the Upper Jurassic suggests a direct relationship with *Scriniiodinium*, from which it may well have evolved by enlargement of the archaeopyle.

Cavate cyst sp. indet A

Plate 16, figure 3

**DESCRIPTION:** The periblast is broadly ovoidal, with a well developed anterior

pericoel. The endoblast is spherical. There are no apical or antapical projections; tabulations is not indicated. The relatively narrow cingulum divides the cyst unequally; the epitract is longer than the hypotract. The surface of the periblast is perforated; the endoblast has a granular surface. An archaeopyle was not observed.

FIGURED SPECIMEN: I.G.S. slide PK.102C, sample WB 2, from H.M. Geological Survey Borehole, Warlingham, Surrey, at 2959 ft 5 in. depth. Lower Kimmeridgian (Mutabilis Zone).

DIMENSIONS: Figured specimen: periblast length  $63\mu$ , breadth  $52\mu$ , endoblast length  $48\mu$ , breadth  $49\mu$ .

REMARKS: This observation was based on a single specimen. In its general shape, it looks similar to members of *Deflandrea* and *Hexagonifera*, but an archaeopyle was not observed. It may represent a new genus, but before this can be decided, better preserved specimens must be awaited.

#### Cavate cyst sp. indet. B

##### Plate 16, figures 2, 4

DESCRIPTION: The cyst is broadly ovoidal to elongate in shape, bearing a short, blunt, hollow apical horn, and one or two antapical horns. The endoblast is sub-spherical to spherical, with rounded ends. Tabulation and sulcus are not indicated. The broad cingulum divides the cyst unequally: the epitract is longer than the hypotract. The periphragm is densely perforated. The endophragm is smooth or minutely granular. An irregular breakage on the epitract, suggesting the beginning of opening of an apical or intercalary archaeopyle, was observed in some of the specimens.

FIGURED SPECIMENS: I.G.S. slide PK.104, sample WB 4, from Warlingham Borehole at 2910 ft 6 in. depth; and I.G.S. slide PK 106, sample WB 5, from the Borehole at 2885 ft 1 in. depth. Lower Kimmeridgian (Eudoxus Zone).

DIMENSIONS: Range (22 specimens were measured): overall length  $45-70\mu$ , breadth  $33-60\mu$ , endoblast length  $33-53\mu$ , breadth  $31-50\mu$ .

REMARKS: A group of specimens (44 in number), all from the Lower Kimmeridgian (Mutabilis to Pectinatus) of the Warlingham Borehole, were recorded which resemble, in their general appearance (with apical and antapical projections) the species of the genus *Deflandrea*. However, since no regular archaeopyle formation was observed, they are not attributed to that genus: they may indeed well be representatives of a new genus. The cavate cyst sp. indet. A (previously mentioned) shows similarities to these specimens, in their perforated periphragm and similar overall appearance, but has no projections at the apex and the antapex.

## INCERTAE SEDIS

Group **ACRITARCHA** Evitt, 1963Subgroup **ACANTHOMORPHITAE** Downie, Evitt & Sarjeant, 1963Genus **MICRHYSTRIDIUM** Deflandre, emend. Sarjeant, 1967c***Micrhystridium recurvatum*** Valensi, 1953

## Plate 17, figures 1-2

- 1953 *Micrhystridium recurvatum* Valensi, 43, pl. 6, figs 1-4, pl. 10, fig. 10.  
 1955 *M. recurvatum* Valensi; Valensi, 589, pl. 1, fig. 10.  
 1960c *M. recurvatum* Valensi; Sarjeant, 392, pl. 14, fig. 19, text-fig. 1a, table 2.  
 1962b *M. recurvatum* Valensi; Sarjeant, 489, text-figs 8b, f, tables 2-3.  
 1963 *M. recurvatum* Valensi; Wall & Downie, 778.  
 1964 *M. recurvatum* Valensi; Downie & Sarjeant, 133.  
 1964 *M. recurvatum* Valensi; Sarjeant, table 4.  
 1964 *M. recurvatum* Valensi; Gocht, 123, pl. 16, fig. 13, text-fig. 43.  
 1965b *M. recurvatum* Valensi; G. & M. Deflandre, fiches 2346-2351.  
 1965 *M. recurvatum* Valensi; Sarjeant, 177-178, pl. 1, figs 11-18, table 1.  
 1967 *M. recurvatum* Valensi; Dodekova, 27, pl. 3, fig. 10, table 1.  
 1967c *M. recurvatum* Valensi; Sarjeant, pl. 1, figs 1, 3-5, 9, text-fig. 1H.  
 1968 *M. recurvatum* Valensi; Sarjeant, table 2A.

**DESCRIPTION:** The cyst is spherical to subspherical, bearing simple, hollow, distally closed, curved processes, about 32-38 in number. The surface of the cyst is smooth or very finely granular.

**FIGURED SPECIMEN:** I.G.S. slide PK.127, sample WB 26, from H.M. Geological Survey Borehole, Warringham, Surrey, at 2359 ft 9 in. depth. Upper Kimmeridgian (Pectinatus Zone).

**DIMENSIONS:** Figured specimen: diameter  $10\mu$ , process length  $4\mu$ . Range: diameter 13-20 $\mu$ , process length 3-12 $\mu$ , measured specimens 29 in number. Valensi gave the holotype diameter as  $10\mu$ , Sarjeant gave the mean diameters of the specimens from Normandy as  $14\mu$ . In contrast, Dodekova gave the average diameters of her Kimmeridgian specimens from Bulgaria as 22 $\mu$ ; these specimens appear well outside the normal size range and may well represent a distinct species.

**OBSERVED RANGE:** Lower to Upper Kimmeridgian (Cymodoce to Rotunda). Not yet observed from the Elegans and Scitulus Zones.

**TOTAL KNOWN RANGE:** Bajocian to Upper Kimmeridgian (Rotunda Zone).

***Micrhystridium* sp.**

## Plate 17, figures 7-8

- 1970 *Micrhystridium inconspicuum* Gitmez, pl. 1, fig. 8, table 4.

**DESCRIPTION:** A form of *Micrhystridium* having a spherical shell, with thick shell wall (c.  $1\mu$ ). Processes are simple, conical, about 30 in number, and slightly curved.

The length of the processes is not more than one quarter of the shell diameter; they are hollow, distally closed, their cavity connected to the shell interior. The surface of the shell is smooth. An opening in the form of a split was observed in the single specimen seen.

FIGURED SPECIMEN: BM(NH) slide V.53953(1), sample OM 418, from 10 ft above the Ringstead Coral Bed, Osmington Mills, Dorset. Lower Kimmeridgian (Baylei Zone).

DIMENSIONS: Figured specimen: shell diameter  $19 \times 20\mu$ , process length  $4-5\mu$ .

REMARKS: A single specimen recorded from the Baylei Zone of Dorset, was earlier placed into *M. inconspicuum* (Gitmez, 1970); subsequently, examination by high power objective has shown that it is different from *M. inconspicuum* as recently redefined by Deflandre and Sarjeant (1970).

With its short processes, this specimen is similar to the Oxfordian species *M. rarispinum* Sarjeant (1960c). However, its cyst diameter is greater than that of *M. rarispinum* and its processes are slightly longer and more numerous (Sarjeant gave the cyst diameter of the latter species as  $11\mu$ , process length  $2-2.5\mu$  and the process number as 14-20). It may represent a new species, but more specimens must be awaited.

Genus **SOLISPHAERIDIUM** Staplin, Jansonius & Pocock, 1965 emend. Sarjeant, 1968b

***Solisphaeridium claviculorum*** (Deflandre) Sarjeant, 1968b

Plate 17, figures 9-10

- 1938e *Hystrichosphaeridium claviculorum* Deflandre, 191-2, pl. 10, fig. 4.
- 1963 *Baltisphaeridium claviculorum* (Deflandre); Downie & Sarjeant, 91.
- 1964 *B. claviculorum* (Deflandre); Downie & Sarjeant, 88
- 1964 *B. claviculorum* (Deflandre); Sarjeant, table 3.
- 1966 *B. claviculorum* (Deflandre); Davey, Downie, Sarjeant & Williams, 174.
- 1968 ?*Solisphaeridium claviculorum* (Deflandre); Sarjeant, 233, pl. 2, figs 13, 15, table 2A.
- 1970 *S. claviculorum* (Deflandre); Deflandre & Sarjeant, 6, pl. 1, fig. 5.

DESCRIPTION: Cyst spheroidal, moderately thin-walled, bearing about 22 processes. These processes are simple and straight, their length about four-fifths of the cyst diameter; they are closed at both the distal and the proximal ends but contain an elongate cavity which does not connect to the central cavity of the shell. The surface of the cyst is finely granular. An opening, in the form of a split, was observed.

FIGURED SPECIMEN: I.G.S. slide PK.101, sample WB 1, from H.M. Geological Survey Borehole, Warlingham, Surrey, at 2984 ft 7 in. depth. Lower Kimmeridgian (Mutabilis Zone).

DIMENSIONS: Shell  $18 \times 20\mu$ , process length  $17\mu$ . Holotype: overall diameter  $58\mu$ , process length  $14-16\mu$  (as given by Deflandre).

REMARKS: A single specimen of this species was originally recorded from the Upper Jurassic of France and attributed to the genus *Hystrichosphaeridium*. In 1963,



Downie and Sarjeant transferred it to the genus *Baltisphaeridium* on the basis of its spine characters. Recently, one of the authors (W.A.S.S., 1968b), after re-examination of the holotype and recording further specimens from the Lower Oxfordian, placed this species in the genus *Solisphaeridium* hesitantly, because of the absence of clear knowledge of the mode of archaeopyle formation. Subsequent study of the holotype has since confirmed his judgement (Deflandre and Sarjeant, 1970).

A single specimen was observed in the Warlingham Borehole sample from the Mutabilis Zone which conforms in morphology to this species; since only one specimen was found, the presence of the species at this level, after such a stratigraphic hiatus, cannot be regarded as definite since pollution cannot be altogether ruled out.

### Subgroup **NETROMORPHITAE** Downie, Evitt & Sarjeant, 1963

#### Organism A

Plate 16, figure 1; plate 17, figure 3

1970 Organism A Gitmez, 321, pl. 11, figure 9, table 4.

**DESCRIPTION:** The cyst is ellipsoidal to elongate. One pole is rounded, the other is flattened: the lateral walls are slightly outbowed. The cyst wall is thick (about  $1\mu$ ), without ornamentation, processes or division into fields. The surface is smooth but porate; distribution of the pores is irregular, being generally densest around the flattened pole and on the sides of the cyst. An opening was observed in the flattened pole: its outline appears to be roughly circular.

**FIGURED SPECIMEN:** BM(NH) slide V.53948(3), sample RB 219, from the *Rhactorhynchia inconstans* Bed, Ringstead Bay, Dorset, Lower Kimmeridgian (Baylei Zone).

**DIMENSIONS:** Figured specimen: cyst length  $77\mu$ , breadth  $28\mu$ . Range: length  $42-77\mu$ , breadth  $18-48\mu$ . Measured specimens 12 in number.

**REMARKS:** This new form was observed in the assemblages from the Baylei and Mutabilis Zones of Dorset and Le Havre only. It resembles in general outline members of the genus *Palaeostomocystis*, especially the species *P. laevigata* Drugg, 1967 (Upper Cretaceous of California): but none of the specimens observed contains an internal cyst or sac-like body.

### Subgroup **PTEROMORPHITAE** Downie, Evitt & Sarjeant, 1963

#### Genus **PTEROSPERMOPSIS** W. Wetzel, 1952

#### *Pterospermopsis harti* Sarjeant, 1960c

Plate 17, figure 6

1960c *Pterospermopsis harti* Sarjeant, 402-3, pl. 14, fig. 16, text-fig. 3, table 2.

1962b *P. harti* Sarjeant; Sarjeant, table 3.

1964 *P. harti* Sarjeant; Downie & Sarjeant, 143.

**FIGURED SPECIMEN:** I.G.S. slide PK.III, sample WB 8, from H.M. Geological Survey Borehole, at 2810 ft 6 in. depth. Lower Kimmeridgian (Eudoxus Zone).

**DIMENSIONS:** Figured specimen: overall  $30 \times 30\mu$ , cyst  $12 \times 12\mu$ . Overall dimensions of the other English specimen  $32 \times 32\mu$ , cyst  $17 \times 17\mu$ . French specimen: overall  $30 \times 30\mu$ , cyst  $12 \times 12\mu$ .

**OBSERVED RANGE:** Lower to Upper Kimmeridgian (Eudoxus to Pectinatus). (See below.) **Total Known Range:** Upper Oxfordian (Pseudocordata) to Upper Kimmeridgian (Pectinatus).

**REMARKS:** This species was originally recorded from the Corallian of Yorkshire. It is very rare in the Kimmeridgian, only three specimens being recorded, one each from France (Mutabilis), Warlingham Borehole (Eudoxus) and Dorset (Pectinatus Zone).

#### Subgroup **UNCERTAIN**

Acritarch sp. indet.

Plate 17, figures 4-5

**DESCRIPTION:** The cyst is elongate, ovoidal with rounded ends, bearing about 14-16 processes. These processes are simple, straight or slightly curved, conical and closed distally. The shell wall is composed of two layers, the outer layer forming the processes; the processes are hollow but their cavities are not in contact with the central cavity. The surface of the cyst is smooth or minutely granular. An irregular opening was observed.

**FIGURED SPECIMENS:** I.G.S. slides PK.125 and PK.126, sample WM 26, from H.M. Geological Survey Borehole, Warlingham, Surrey, at 2359 ft 9 in. depth. Upper Kimmeridgian (Pectinatus Zone).

**DIMENSIONS:** Range: Shell length  $15-35\mu$ , breadth  $8-15\mu$ , process length  $6-10\mu$ . Measured specimens 5 in number.

**REMARKS:** All the specimens were recorded from the same horizon in the Warlingham Borehole (Pectinatus Zone). They differ from described species in their elongate shape and irregular opening. They may represent a new species and perhaps even a new genus.

#### IV. STRATIGRAPHICAL DISTRIBUTION CHARTS

See Tables 3 to 6.

#### V. CONCLUSIONS

In the Kimmeridgian samples from England, Scotland and France described by Gitmez (1970) and herein, 36 genera, comprising 110 species, of dinoflagellate cysts and 6 genera, comprising 16 species, of acritarchs were recognised. From these, two new genera, 23 new species and 4 new varieties have been proposed: more than a dozen other forms certainly represent new species but were not proposed as such, because of poor preservation or (more frequently) inadequate numerical representation. In addition, there was a further list of species, probably new, whose preservation, presentation or orientation entirely precluded their description: the microplankton of the Kimmeridgian Stage is thus much more rich and more varied than has hitherto been recognised.





TABLE 3  
The numerical distribution of microfossils in the Kimmeridgian assemblages from Dorset, Oxfordshire, Cambridgeshire and Scotland (Staffin Bay and Cromarty)

	DORSET																				CAM-BS.	OXFORD-SHIRE			SCOTLAND				
	Baylei Zone						Autissio-dorensis Zone		Elegans Zone	Scitulus Zone	Wheatleyensis Zone	Hudleston-Pectin.	Pectinatus Zone			Rotunda Zone		Baylei Zone	Pallasioides Zone			Baylei Zone	Cymodoce Zone						
	OM 131	OM 418	OM 419	OM 420	HD 191	RB 218	RB 219	KD 221	KD 224	KD 225	KD 227	CD 229	CH 231	RD 234	FD 236	FD 237	ED 240		ED 242	HC 243			CP 245	HC 246	SC 444	LO 352	LO 353	LO 360	SS 625
Chytroesphaeridia chytroides	21	17	14	16				24		14	3	1	6	2	28	4	1	24	17	77	13	18	4	20		17	11	8	9
C. mantelli	10	3	1	1				5		51	9		10		16		11	8	12	3	6	4	3	4		5	7	6	1
C. pococki													24					1											3
Fromea warlinghamensis			1				1	7											3	1				1	2				
Tenua capitata	1																												
T. echinata	15	3	1	1		1	9						4		4	1		11	19			12	11	27		5	1	3	35
T. hystrix	10	1	3				7								3				6	7		9	1	2		4	2	1	1
T. pilosa																													
T. sp.		1																		6		1							1
Acanthaulax venusta																													
Cryptarchaeodinium calcaratum																													
C. cf. calcaratum																													
Gonyaulacysta aculeata																													
G. angulosa																													
G. cauda																													
G. cladophora																													
G. eisenacki	4																												
G. cf. eisenacki	2																												
G. globata																													
G. granulata		1																											
G. graniligera		3	3	2	2	7																							
G. cf. helicoidea																													
G. hyaloderma	3	3	6	20	1	49	63																						
G. jurassica																													
G. jurassica var. longicornis																													
G. longicornis																													
G. cf. mamillifera	2	3	2	1	1		11		16	16	5	3	3		13	2	19	4	2	1		4		4					
G. nucleiformis																													
G. perforans	1		1	1																									
G. serrata																													
G. sp. A																													
G. sp. D																													
G. sp. F																													
G. sp. G																													
G. sp. H																													
Leptodinium aceras																													
L. amabilis																													
L. arcuatum	2																												
L. cf. crassinervium	10	6	1			2	1	1																					
L. egemeni	2																												
L. cf. subtile																													
L. sp.																													
Occisacysta balios																													
O. monoheuristicos																													
O. sp. (Gitzert, 1970)																													
Belodinium dysculum	1																												
Dictyopyxus areolata	2																												
D. cf. reticulata																													
Histiophora cf. ornata																													
Meiourononyaulax dictyptos																													
M. pila																													
M. staflinensis	3																												
M. sp. A (Gitzert, 1970)																													
M. sp. B, herein																													
Apteodinium granulatum																													
A. cf. maculatum																													
Pareodinia ceratophora	8	5	4	5			5	13	18		23	5	5	2		10	2	5	14	21	2	1							
Trichodinium sp.																													
Imbatodinium antennatum	1																												
I. cf. villosum																													
Nannoceratopsis pellucida	2																												
Egmontodinium polyplacophorum																													
Proximate cyst sp. indet.																													
Heslertonia pellucida																													
Epiplosphaera reticulosponosa	2	1	1	1																									
Adnatosphaeridium paucispinum											</																		





TABLE 4  
The numerical distribution of microfossils in the Kimmeridgian assemblages from the Warlingham Borehole, Surrey

	Mutabilis Zone					Eudoxus Zone							Autissiodorensis Zone				Elegans Zone	Scitulus Zone				Wheatleyensis Zone				Hudlestoni Zone			Pectinatus Zone			Rotunda Zone		
	WB 1	WB 2	WB 3	WB 4	WB 5	WB 6	WB 7	WB 8	WB 9	WB 10	WB 11	WB 12	WB 13	WB 14	WB 15	WB 16	WB 17	WB 18	WB 19	WB 20	WB 21	WB 22	WB 23	WB 24	WB 25	WB 26	WB 27	WB 28	WB 29					
Chytroisphaeridia chytroides	33	11	49	61	42	94	39	23	27	62	31	26	50	50	31	63	18	14	27	5	3	17	29	27	35	37	9	17	7					
C. mantelli	2	2	6	3	7		7	8	5	17	12	5	4	2	5			1	27	5	3	17	29	27	35	37	9	17	7					
C. pococki																																		
Fromea warlinghamensis																																		
Tenua capitata		2																																
T. echinata																																		
T. hystrix		2		3																														
T. pilosa		6																																
Gonyaulacysta angulosa																																		
G. cladophora																																		
G. ehrenbergii																																		
G. cf. giuseppi		3																																
G. globata																																		
G. granulata	1	2	1	2																														
G. granuligera																																		
G. jurassica	1		1																															
G. jurassica var. longicornis																																		
G. longicornis	1	1																																
G. cf. mamillifera																																		
G. nuciformis	6						5	2	7																									
G. perforans																																		
G. sp. B																																		
G. sp. C																																		
G. sp. E																																		
Leptodinium aceras																																		
L. arcuatum																																		
L. sp.																																		
Occisucysta balios		5																																
Histiophora cf. ornata																																		
Meiourögonyaulax pila																																		
M. staffinensis																																		
M. sp. herein																																		
Apteodinium granulatum																																		
A. cf. maculatum																																		
Pareodinia ceratophora	5	6	4	2	3																													
Imbatodinium antennatum																																		
Proximate cyst sp. indet.																																		
Cleistosphaeridium ehrenbergi	2	3																																
C. polyacanthum																																		
C. tribuliferum																																		
C. sp. herein																																		
Hystichosphaeridium petilum		3																																
Prolixosphaeridium granulatum																																		
P. parvispinum																																		
Systematophora areolata		23		2																														
S. orbifera		2																																
Endoscrinium luridum																																		
E. oxfordianum																																		
Psaligonyaulax apaleta																																		
Hexagonifera jurassica																																		
Parvocavatus tuberosus																																		
Muderoogia simplex																																		
Scribneridium bicuneatum																																		
S. crystallinum																																		
S. dictyotum subsp. papillatum																																		
S. playfordi																																		
S. sp.																																		
Netrellytron parum																																		
Cavate cyst sp. indet. A																																		
Cavate cyst sp. indet. B																																		
Micrhystridium fragile	66	5	9	6	8		2		2																									
M. inconspicuum	2	2	1	3																														









